01 SOLID FUELS

Sources, winning, properties

10/02574 Attenuation and diel cycling of coal-mine drainage constituents in a passive treatment wetland: a case study from Lambert Run, West Virginia, USA

Vesper, D. J. and Smilley, M. J. *Applied Geochemistry*, 2010, 25, (6), 795–808.

This study reports changes in coal-mine drainage constituent concentrations through a passive treatment wetland and over diel cycles. The purpose of the study was to determine what physiochemical mechanisms control attenuation of metals and if they varied by location and through time. The source water was slightly acidic (average pH 5.43); downstream degassing of CO_2 contributed to an increase in pH prior to discharge from the site (average pH 7.05). Aluminium, Fe, rare earth elements (REE) and Y were removed to a greater extent than were Mn, Co and Ni. At acidic pH, the REE and Y were generally complexed by SO_4. At higher pH, carbonate complexes became more important. The REE and Y concentrations were normalized to the North American Shale Composite standard; the normalized patterns were coherent near the source but anomalies of Ce and Y were present further downstream indicating oxidation and sorption processes. Four sets of diel-based samples were collected, one from a shallow, surface-flow wetland and three from a deeper, newly constructed wetland. Well-defined diel cycles were observed for concentrations of Si, Mn, Fe, Co, Ni, As, REE and Y in the shallow wetland. In all cases, the concentrations increased (up to 863%) during night and decreased during the day. These cycles had an inverse relationship with the temperature cycle (pH had no discernable cycle). The consistency of concentration cycles suggests a common mechanism, most likely associated with the formation of Fe oxyhydroxides. The increased rate of Fe^{2+} oxidation in warm water can account for the cycles in Fe; scavenging of the other elements by the Fe precipitate can account for the consistency of the cycles even though the elements include cations, anions ($H_2AsO_4^-$ or $HAsO_4^{-2}$), and neutral species ($H_4SiO_4^0$). While REE and Y had clear cycles in the constructed wetland, the other elements did not. This is partially due to the lower elemental concentrations (including Fe) but the cycles may also be damped by the deeper, slower-moving water. This study illustrates the dynamic nature of metal removal in passive treatment systems. Furthermore, it suggests that grab samples collected during daytime hours may underestimate the concentrations and flux of metals in these systems.

10/02575 High-pressure sorption isotherms and sorption kinetics of CH_4 and CO_2 on coals

Li, D. *et al. Fuel*, 2010, 89, (3), 569–580.

Using a manometric experimental setup, high-pressure sorption measurements with CH_4 and CO_2 were performed on three Chinese coal samples of different rank ($VR_r = 0.53\%$, 1.20%, and 3.86%). The experiments were conducted at 35, 45, and 55 °C with pressures up to 25 MPa on the 0.354–1 mm particle fraction in the dry state. The objective of this study was to explore the accuracy and reproducibility of the manometric method in the pressure and temperature range relevant for potential coalbed methane (CBM) and CO_2-enhanced CBM (CO_2-ECBM) activities ($P > 8$ MPa, $T > 35$ °C). Maximum experimental errors were estimated using the Gauss error propagation theorem, and reproducibility tests of the high-pressure sorption measurements for CH_4 and CO_2 were performed. Further, the experimental data presented here was used to explicitly study the CO_2 sorption behaviour of Chinese coal samples in the elevated pressure range (up to 25 MPa) and the effects of temperature on supercritical CO_2 sorption isotherms. The experiments provided characteristic excess sorption isotherms which, in the case of CO_2 exhibit a maximum around the critical pressure and then decline and level out towards a constant value. The results of these manometric tests are consistent with those of previous gravimetric sorption studies and corroborate a crossover of the 35, 45, and 55 °C CO_2 excess sorption isotherms in the high-pressure range. The measurement range could be extended, however, to significantly higher pressures. The excess sorption isotherms tend to converge, indicating that the temperature dependence of CO_2 excess sorption on coals at high-pressures (> 20 MPa) becomes marginal. Further, all CO_2 high-pressure isotherms measured in this study were approximated by a three-parameter excess sorption function with special consideration of the density ratio of the 'free' phase and the sorbed phase. This function provided a good representation of the experimental data. The maximum excess sorption capacity of the three coal samples for methane ranged from 0.8 to 1.6 mmol/g (dry, ash-free) and increased from medium volatile bituminous to subbituminous to anthracite. The medium volatile bituminous coal also exhibited the lowest overall excess sorption capacity for CO_2. However, the subbituminous coal was found to have the highest CO_2 sorption capacity of the three samples. The mass fraction of adsorbed substance as a function of time recorded during the first pressure step was used to analyse the kinetics of CH_4 and CO_2 sorption on the coal samples. CO_2 sorption proceeds more rapidly than CH_4 sorption on the anthracite and the medium volatile bituminous coal. For the subbituminous coal, methane sorption is initially faster, but during the final stage of the measurement CO_2 sorption approaches the equilibrium value more rapidly than methane.

10/02576 Investigations into the ignition behaviors of pulverized coals and coal blends in a drop tube furnace using flame monitoring techniques

Chi, T. *et al. Fuel*, 2010, 89, (3), 743–751.

This paper presents experimental investigations into the ignition behaviours of pulverized coals and coal blends in a drop tube furnace using a flame monitoring system. Seven different ranks of coals and coal blends of different mixing proportion were tested. Characteristic parameters including relative ignition temperature, maximum ignition points, oscillation frequency, fluctuation ratio and combustion dynamic energy were determined from the flame monitoring system. The ignition behaviours of the coals are established by combining the parameters. Results demonstrate that the parameters are suitable for distinguishing ignition behaviours from homogeneous, hetero–homogeneous to heterogeneous in the ignition section of a drop tube furnace. The ignition behaviours of a coal blend are found to have similar characteristics as the coal of higher volatile matter in the blend and depend on its proportion in the blend. The results from this study are used to predict the operation of a coal-fired power plant in terms of fuel selection, fuel blending, and flame stability.

10/02577 Variation on anthracite combustion efficiency with CeO_2 and Fe_2O_3 addition by differential thermal analysis (DTA)

Gong, X. *et al. Energy*, 2010, 35, (2), 506–511.

Effects of CeO_2 and Fe_2O_3 on anthracite combustion efficiency were investigated using differential thermal analysis (DTA). Based on heat release (Q_D) of anthracite as well as anthracite with CeO_2 and anthracite with Fe_2O_3 additions against α-Al_2O_3 in DTA experiment, effects of additives CeO_2 and Fe_2O_3 on anthracite combustion efficiency were evaluated. Under the same experimental conditions, heat releases of raw anthracite, anthracite with CeO_2 and anthracite with Fe_2O_3 were 11.04, 11.30 and 11.42 kJ/g, respectively, indicating that anthracite combustion efficiency was improved by addition of CeO_2 and Fe_2O_3. To confirm the above results, carbon transfer was monitored using Thermogravimetric analysis Fourier transform infrared (TGA-FTIR) and carbon–sulfur analyser during catalytic combustion process. The results indicated that CO_2 emission was increased, whereas CO emission and residual carbon of ash were decreased, being in accordance with the results of DTA. Finally, according to analyses of ignition temperature and catalytic combustion process, the possible mechanism of catalytic combustion of anthracite was proposed.

Preparation

10/02578 Combustion and emission characteristics of ethanol–biodiesel–water micro-emulsions used in a direct injection compression ignition engine

Qi, D. H. *et al. Fuel*, 2010, 89, (5), 958–964.

This work aims on the efficient use of ethanol–biodiesel–water micro-emulsions in a diesel engine. A single cylinder direct injection diesel engine is tested using neat biodiesel and the micro-emulsions as fuels under variable operating conditions. The results indicate that, compared with biodiesel, the peak cylinder pressure of the micro-emulsions is almost identical, and the peak pressure rise rate and peak heat release rate are higher at medium and high engine loads. At low engine loads, those of the micro-emulsions are lower. The start of combustion is later for the micro-emulsions than for biodiesel. For the micro-emulsions, there is slightly higher brake specific fuel consumption (BSFC), while lower brake specific energy consumption (BSEC). Drastic reduction in smoke is observed with the micro-emulsions at high engine loads. Nitrogen oxide (NO_x) emissions are found slightly lower under all rang of engine load for the micro-emulsions. But carbon monoxide (CO) and hydrocarbon (HC) emissions are slightly higher for the micro-emulsions than that for biodiesel at low and medium engine loads.

10/02579 Mercury emission from coal-fired power plants in Poland

Glodek, A. and Pacyna, J. M. *Atmospheric Environment*, 2009, 43, (35), 5668–5673.

The paper reviews the current state of knowledge regarding sources of mercury emission in Poland. Due to the large quantities of coal burned at present, as well as taking into account existing reserves, coal remains the main energy source of energy in Poland. The data on coal consumption in Poland in the past, at present and in the future are discussed in the paper. Information on the content of mercury in Polish coals is presented. Coal combustion processes for electricity and heat production are the main source of anthropogenic mercury emission in Poland. It is expected that the current emissions will decrease in the future due to implementation of efficient control measures. These measures for emission reduction are described in the paper. Results of estimated mercury emission from coal-fired power station situated in the Upper Silesia Region, Poland are investigated. A relationship between mercury emission to the air and the mercury content in the consumed coal in power station equipped with the electrostatic precipitators (ESPs) is discussed.

Economics, business, marketing, policy

10/02580 A long-term view of worldwide fossil fuel prices

Shafiee, S. and Topal, E. *Applied Energy*, 2010, 87, (3), 988–1000.

This paper reviews a long-term trend of worldwide fossil fuel prices in the future by introducing a new method to forecast oil, natural gas and coal prices. The first section of this study analyses the global fossil fuel market and the historical trend of real and nominal fossil fuel prices from 1950 to 2008. Historical fossil fuel price analysis shows that coal prices are decreasing, while natural gas prices are increasing. The second section reviews previously available price modelling techniques and proposes a new comprehensive version of the long-term trend reverting jump and dip diffusion model. The third section uses the new model to forecast fossil fuel prices in nominal and real terms from 2009 to 2018. The new model follows the extrapolation of the historical sinusoidal trend of nominal and real fossil fuel prices. The historical trends show an increase in nominal/real oil and natural gas prices plus nominal coal prices, as well as a decrease in real coal prices. Furthermore, the new model forecasts that oil, natural gas and coal will stay in jump for the next couple of years and after that they will revert back to the long-term trend until 2018.

10/02581 Economic analysis of coal-based polygeneration system for methanol and power production

Lin, H. *et al. Energy*, 2010, 35, (2), 858–863.

Polygeneration system for chemical and power co-production has been regarded as one of promising technologies to use fossil fuel more efficiently and cleanly. In this paper the thermodynamic and economic performances of three types of coal-based polygeneration system were investigated and the influence of energy saving of oxygenation systems on system economic performance was revealed. The primary cost saving ratio (PCS) is presented as a criterion, which represents the cost saving of polygeneration system compared with the single-product systems with the same products outputs, to evaluate economic advantages of polygeneration system. As a result, the system, adopting un-reacted syngas partly recycled to the methanol synthesis reactor and without the shift process, can get the optimal PCS of 11.8%, which results from the trade-off between the installed capital cost saving and the energy saving effects on the cost saving, and represents the optimal coupling relationship among chemical conversion, energy utilization and economic performance. And both of fuel price and the level of equipment capital cost affect on PCS faintly. This paper provides an evaluation method for polygeneration systems based on both technical and economic viewpoints.

10/02582 Optimal fossil-fuel taxation with backstop technologies and tenure risk

Strand, J. *Energy Economics*, 2010, 32, (2), 418–422.

This paper derives the global welfare-optimizing time path for a tax on fossil fuels causing a negative stock externality (climate change), under increasing marginal extraction cost, and in the presence of an unlimited backstop resource causing no externality. In a basic competitive case, the optimal tax equals the Pigou rate, equivalent to the present discounted value of marginal damage costs. The authors consider two separate types of tenure insecurity for resource owners, and their impact on the tax implementing the optimal policy. When insecure control is with respect to future ownership to the resource, competitive extraction is higher than otherwise, and the efficiency-implementing tax exceeds the Pigou rate. When tenure insecurity instead implies possible expropriation ('holdup') of investment in extraction capacity, it deters extraction, and the optimal tax is lower than the Pigou rate.

10/02583 Petrochemicals from oil, natural gas, coal and biomass: production costs in 2030–2050

Ren, T. *et al. Resources, Conservation and Recycling*, 2009, 53, (12), 653–663.

Methane, coal and biomass are being considered as alternatives to crude oil for the production of basic petrochemicals, such as light olefins. This paper is a study on the production costs of 24 process routes utilizing these primary energy sources. A wide range of projected energy prices in 2030–2050 found in the open literature is used. The basis for comparison is the production cost per t of high value chemicals (HVCs or light olefin-value equivalent). A Monte Carlo method was used to estimate the ranking of production costs of all 24 routes with 10,000 trials of varying energy prices and CO_2 emissions costs (assumed to be within \$0–100/t CO_2; the total CO_2 emissions, or cradle-to-grave CO_2 emissions, were considered). High energy prices in the first three-quarters of 2008 were tested separately. While the production costs of crude oil- and natural gas-based routes are within \$500–900/t HVCs, those of coal- and biomass-based routes are mostly within \$400–800/t HVCs. Production costs of coal- and biomass-based routes are in general quite similar while in some cases the difference is significant. Among the top seven most expensive routes, six are oil- and gas-based routes. Among the top seven least expensive routes, six are coal and biomass routes. The effect of CO_2 emissions costs was found to be strong on the coal-based routes and also quite significant on the biomass-based routes. However, the effect on oil- and gas-based routes is found to be small or relatively moderate. The results of the review of energy prices in 2008 found that most of the coal-based routes and biomass-based routes (particularly sugar cane) still have much lower production costs than the oil- and gas-based routes (even if international freight costs are included). To ensure the reduction of CO_2 emissions in the long term, it is suggested that policies for the petrochemicals industry focus on stimulating the use of biomass as well as carbon capture and storage features for coal-based routes.

10/02584 Planning India's long-term energy shipment infrastructures for electricity and coal

Bowen, B. H. *et al. Energy Policy*, 2010, 38, (1), 432–444.

The Purdue long-term electricity trading and capacity expansion planning model simultaneously optimizes both transmission and generation capacity expansions. Most commercial electricity system planning software is limited to only transmission planning. An application of the model to India's national power grid, for 2008–2028, indicates substantial transmission expansion is the cost-effective means of meeting the needs of the nation's growing economy. An electricity demand growth rate of 4% over the 20-year planning horizon requires more than a 50% increase in the government's forecasted transmission capacity expansion, and 8% demand growth requires more than a six-fold increase in the planned transmission capacity expansion. The model minimizes the long-term expansion costs (operational and capital) for the nation's five existing regional power grids and suggests the need for large increases in load-carrying capability between them. Changes in coal policy affect both the location of new thermal power plants and the optimal pattern inter-regional transmission expansions.

Derived solid fuels

10/02585 Converter slag–coal cinder columns for the removal of phosphorous and other pollutants

Yang, J. *et al. Journal of Hazardous Materials*, 2009, 168, (1), 331–337.

A mixture of converter slag and coal cinder as adsorbent for the removal of phosphorous and other pollutants was studied in the paper. The maximum P adsorption capacity, pH of solution, contact time and initial phosphate concentration were evaluated in batch experiments for the two materials firstly. The data of P sorption were best fitted to Langumir equation, and the maximum adsorption capacities of converter slag and coal cinder were 2.417 and 0.398 mg P/g, respectively. The pH of solutions with converter slag and coal cinder changed dramatically with time and closed to 8 in 8 h, and the influence of initial pH on phosphate removal by coal cinder was more significant than by converter slag. Phosphate removal rate by converter slag decreased with increase of initial phosphate concentrations. Subsequently, two flow-through columns (Column 1#, $V_{\text{converter slag}}:V_{\text{coal cinder}} = 1:5$; Column 2#, $V_{\text{converter slag}}:V_{\text{coal cinder}} = 1:3$) were operated for the removal of phosphorous and other pollutants from the effluents of a vermifilter for nearly eleven months. Results indicated the average removal efficiency of total phosphorus, dissolved phosphorus, COD and $NH_4{}^+$–N by Column 1# were 44%, 56%, 31% and 67%, and by Column 2# were 42%, 54%, 24% and 57%, respectively. Column 1# had higher removal efficiency for P and other pollutants.

10/02586 Investigation on the structure and the oxidation activity of the solid carbon produced from catalytic decomposition of methane

Chen, J. *et al. Fuel*, 2010, 89, (5), 943–948.

The structure and the oxidation activity of the solid carbon produced from catalytic decomposition of methane at different temperatures were investigated using TEM, XRD, Raman and TPO techniques. The results show that the graphitization degree of the solid carbon is increased with decomposition reaction temperature. The addition of ethylene or acetylene to methane can change the growth way of the solid carbon and decrease their graphitization degree. The average oxidation temperature of the solid carbon has a close relationship with the corresponding graphitization degree. The addition of ethylene or acetylene to methane can decrease the average oxidation temperature of the solid carbon.

10/02587 Naphthalene as an alternative carbon source for pyrolytic synthesis of carbon nanostructures

Charinpanitkul, T. *et al. Journal of Analytical and Applied Pyrolysis*, 2009, 86, (2), 386–390.

The utilization of naphthalene as an alternative carbon source for synthesis of carbon nanoparticles by pyrolysing with ferrocene in a quartz tube reactor was experimentally investigated. Carbon nanoparticles including carbon nanotubes (CNTs) and carbon nanocapsules (CNCs), which contained Fe particles in their carbon shells, were simultaneously fabricated. Transmission electron microscopy (TEM) and scanning electron microscopy (SEM) analyses revealed that morphology and size of the carbon nanostructure strongly depended on the pyrolysis temperature. At a higher temperature, formation of CNCs would become more enhanced. Particle size distribution and yield of the synthesized products were also significantly influenced by the pyrolysis temperature.

10/02588 On the electrochemical performance of anthracite-based graphite materials as anodes in lithium-ion batteries

Cameán, I. *et al. Fuel*, 2010, 89, (5), 986–991.

The electrochemical performance as potential negative electrode in lithium-ion batteries of graphite materials that were prepared from two Spanish anthracites of different characteristics by heat treatment in the temperature interval 2400–2800 °C are investigated by galvanostatic cycling. The interlayer spacing, d_{002}, and crystallite sizes along the c axis, L_c, and the a axis, L_a, calculated from X-ray diffractometry (XRD) as well as the relative intensity of the Raman D-band, I_D/I_t, are used to assess the degree of structural order of the graphite materials. The galvanostatic cycling are carried out in the 2.1–0.003 V potential range at a constant current and C/10 rate during 50 cycles versus Li/Li^+. Larger reversible lithium storage capacities are obtained from those anthracite-based graphite materials with higher structural order and crystal orientation. Reasonably good linear correlations were attained between the electrode reversible charge and the materials XRD and Raman crystal parameters. The graphite materials prepared show excellent cyclability as well as low irreversible charge; the reversible capacity being up to 250 mA h g^{-1}. From this study, the utilization of anthracite-based graphite materials as negative electrode in lithium-ion batteries appears feasible. Nevertheless, additional work should be done to improve the structural order of the graphite materials prepared and therefore, the reversible capacity.

02 LIQUID FUELS

Sources, properties, recovery

10/02589 An experimental investigation of the breakup characteristics of secondary atomization of emulsified fuel droplet

Watanabe, H. *et al. Energy*, 2010, 35, (2), 806–813.

In this study, the breakup characteristics of secondary atomization of an emulsified fuel droplet were investigated with a single droplet experiment. In the single droplet experiment, the emulsified fuel droplet suspended from a fine wire was inserted into an electric furnace, and then secondary atomization behaviour was observed using a high-speed video camera. Moreover, a mathematical model to calculate the generated water vapour at micro-explosion was proposed by using the mass and energy conservation equations under some assumptions. In the proposed model, that can be calculated by using the inner droplet temperature history at micro-explosion. As a result, puffing and micro-explosion occurred even when the fine ceramics fibre was used. The proposed model showed that about 50–70 wt% of water in the emulsified fuel changed to water vapour instantaneously at the occurrence of micro-explosion. The mass of water necessary for micro-explosion was shown. The breakup time was closely related to the superheat temperature just before the occurrence of micro-explosion.

10/02590 Diffusion coefficients of diesel fuel and surrogate compounds in supercritical carbon dioxide

Lin, R. *et al. The Journal of Supercritical Fluids*, 2010, 52, (1), 47–55.

Facilitating a new concept of clean diesel combustion using supercritical fluids requires a better understanding of thermophysical properties of the diesel fuel/diluent system. Mass diffusivity is one such property that is important to understand diesel fuel/diluent mixing and spray and combustion of supercritical fuel mixtures. In this work, diffusion coefficients of diesel fuel and surrogate compounds in supercritical carbon dioxide were experimentally determined by the Taylor dispersion method at temperatures from 313.15 to 373.15 K and pressures up to 30 MPa. Difficulties were encountered to measure diffusion coefficients using the Taylor dispersion method near the critical region of CO_2 which resulted in curve-fitting errors greater than 5%. Predictive correlations including Wilke–Chang, Scheibel, and He–Yu were examined. Diffusivity data were also fitted by $D_{12}/T-\eta$ and $D_{12}\sqrt{}(T)-\rho$ correlations. Results showed that the He–Yu correlation has the best prediction performance while the $D_{12}/T-\eta$ correlation best fits the data with AAD% < 8%.

10/02591 Geochemical characterisation of heavily biodegraded tar sand bitumens by catalytic hydropyrolysis

Sonibare, O. O. *et al. Journal of Analytical and Applied Pyrolysis*, 2009, 86, (1), 135–140.

Catalytic hydropyrolysis was used to release the aliphatic biomarkers covalently bound within the asphaltene structure of highly biodegraded Nigerian tar sand bitumens. Unlike the free aliphatic hydrocarbons extracted from the bitumen, the hydropyrolysis products of the asphaltenes afford aliphatic biomarkers having the characteristics of the initial unaltered oil, which had been trapped within the asphaltene matrix of the bitumen and protected from biodegradation processes. The biomarker profiles obtained allow proper characterization of the bitumen in terms of source and thermal maturity. Catalytic hydropyrolysis is also capable of releasing aromatic hydrocarbons that can be used in the geochemical characterization of the bitumen.

10/02592 Photocatalytic degradation of oil industry hydrocarbons models at laboratory and at pilot-plant scale

Vargas, R. and Núñez, O. *Solar Energy*, 2010, 84, (2), 345–351.

Photodegradation/mineralization (TiO_2/UV Light) of the hydrocarbons: *p*-nitrophenol (PNP), naphthalene (NP) and dibenzothiophene (DBT) at three different reactors: batch bench reactor (BBR), tubular bench reactor (TBR) and tubular pilot-plant (TPP) were kinetically monitored at pH = 3, 6 and 10, and the results compared using normalized UV light exposition times. The results fit the Langmuir–Hinshelwood (LH) model; therefore, LH adsorption equilibrium constants (K) and apparent rate constants (k) are reported as well as the apparent pseudo-first-order rate constants, $k'_{\mathrm{obs}} = kK/(1 + Kc_r)$. The batch bench reactor is the most selective reactor toward compound and pH changes in which the reactivity order is: NP > DBT > PNP, however, the catalyst adsorption (K) order is: DBT > NP > PNP at the three pH used but NP has the highest k values. The tubular pilot-plant (TPP) is the most efficient of the three reactors tested. Compound and pH photodegradation/mineralization selectivity is partially lost at the pilot plant where DBT and NP reaches ca. 90% mineralization at the pH used, meanwhile, PNP reaches only 40%. The real time, in which these mineralization occur are: 180 min for PNP and 60 min for NP and DBT. The mineralization results at the TPP indicate that for the three compounds, the rate limiting step is the same as the degradation one. So that, there is not any stable intermediate that may accumulate during the photocatalytic treatment.

10/02593 Remote bitumen content estimation of Athabasca oil sand from hyperspectral infrared reflectance spectra using Gaussian singlets and derivative of Gaussian wavelets

Lyder, D. *et al. Fuel*, 2010, 89, (3), 760–767.

Modelling of the total bitumen content, TBC, in Athabasca oil sands was undertaken on the basis of its hyperspectral reflectance spectra. Spectra (8 cm^{-1} resolution) were obtained that covered both the short-wave infrared and thermal infrared (TIR: 3.00–30.00 μm). Two methods, Gaussian fitting and wavelet analyses, were investigated to identify useful bitumen features as well as the best removal of the baseline. The aim was aim to obtain the best determination of the TBC for a suitable suite of test and validation oil sands samples. The Gaussian model relied explicitly on features at 2.282 and 2.532 μm though these were only two of 10 features simultaneously fit with a quadratic baseline to the range of 2.230–2.603 μm of the spectra. The wavelet model relied on bitumen features selected at 2.274, 2.396 and 3.725 μm that could be isolated from the baseline and noise. Both models yielded similar dispersion in their estimates of TBC (±~1–2%) while the wavelet model proved to be more robust when applied to the validation and blind data suites. The effects of using the L2 optimization (classical least-squares) and L1 optimization (minimization of largest outlier) schemes for both models were also considered. Both schemes produced similar results for the model suite of samples for TBC but the L1 was superior when applied to the validation and blind data suites. The wavelet model using the L1 optimization appeared to be quite robust producing estimates of TBC (±~1.0–1.7%).

10/02594 Theoretical study of the effects of engine parameters on performance and emissions of a pilot ignited natural gas diesel engine

Papagiannakis, R. G. *et al. Energy*, 2010, 35, (2), 1129–1138.

With the increasing concern regarding diesel vehicle emissions and the rising cost of the liquid diesel fuel as well, more conventional diesel engines internationally are pursuing the option of converting to use natural gas as a supplement for the conventional diesel fuel (dual fuel natural gas/diesel engines). The most common natural gas/diesel operating mode is referred to as the pilot ignited natural gas diesel (PINGD) engine where most of the engine power output is provided by the gaseous fuel while a pilot amount of the liquid diesel fuel injected near the end of the compression stroke is used only as an ignition source of the gaseous fuel–air mixture. The specific engine operating mode, in comparison with conventional diesel fuel operation, suffers from low brake engine efficiency and high carbon monoxide (CO) emissions. In order to be examined the effect of increased air inlet temperature combined with increased pilot fuel quantity on performance and exhaust emissions of a PINGD engine, a theoretical investigation has been conducted by applying a comprehensive two-zone phenomenological model on a high-speed, pilot ignited, natural gas diesel engine located at the authors' laboratory. The main objectives of the present work are to record the variation of the relative impact each one of the above mentioned parameters has on performance and exhaust emissions and also to reveal the advantages and disadvantages each one of the proposed method. It becomes more necessary at high engine load conditions where the simultaneous increase of the specific engine parameters may lead to undesirable results with nitric oxide emissions.

Transport, refining, quality, storage

10/02595 A failure analysis of fillet joint cracking in an oil storage tank

Kim, J.-S. *et al. Journal of Loss Prevention in the Process Industries*, 2009, 22, (6), 845–849.

This paper has studied failure of an oil storage tank. During operation, several cracks were observed at the fillet weldment between reactor shell and annular plates in the bottom of oil storage tank. Extreme stresses in the structure during its operation were determined taking into account shape and geometry imperfections as well as corrosion influence. Both reactor shell and annular plates are made of carbon steel (SM53C). In this study, in order to identify the causes for the fillet weldment cracking, failure analysis such as fractography, tensile test, hardness test, corrosion test (SSRT), chemical analysis was performed. The failure of oil storage tank is the result of the combined and synergistic interaction of mechanical stress and corrosion reactions. Although cracks were initiated by corrosion, failure was generated by propagation of crack caused by stresses concentration. It was recommended that (1) the local stresses be reduced by improved weld toe geometry, and (2) the reinforcement be used in order to avoid failure by stresses concentration.

10/02596 An integrated reliability-based design optimization of offshore towers

Karadeniz, H. *et al. Reliability Engineering & System Safety*, 2009, 94, (10), 1510–1516.

After recognizing the uncertainty in the parameters such as material, loading, geometry and so on in contrast with the conventional optimization, the reliability-based design optimization (RBDO) concept has become more meaningful to perform an economical design implementation, which includes a reliability analysis and an optimization algorithm. RBDO procedures include structural analysis, reliability analysis and sensitivity analysis both for optimization and for reliability. The efficiency of the RBDO system depends on the mentioned numerical algorithms. In this work, an integrated algorithms system is proposed to implement the RBDO of the offshore towers, which are subjected to the extreme wave loading. The numerical strategies interacting with each other to fulfil the RBDO of towers are as follows: (a) a structural analysis program, SAPOS, (b) an optimization program, SQP and (c) a reliability analysis program based on FORM. A demonstration of an example tripod tower under the reliability constraints based on limit states of the critical stress, buckling and the natural frequency is presented.

10/02597 Stability and dynamic analysis of oil pipelines by using spectral element method

Lee, U. *et al. Journal of Loss Prevention in the Process Industries*, 2009, 22, (6), 873–878.

In this paper, the wave characteristics, divergence stability and dynamics of the oil pipelines conveying internal flow are investigated by using the spectral element method which has been known as the exact solution method. The spectral element model is formulated from the governing differential equation of motion transformed into the frequency-domain by using the discrete Fourier transform theory. The internal flow velocity at which the divergence instability occurs is derived in an analytical form. Numerical studies are conducted to investigate the wave characteristics, divergence stability and dynamics of an oil pipeline depending on its viscoelasticity and internal flow velocity.

10/02598 Structural maintenance planning based on historical data of corroded deck plates of tankers

Garbatov, Y. and Soares, C. G. *Reliability Engineering & System Safety*, 2009, 94, (11), 1806–1817.

A probabilistic maintenance and repair analysis of tanker deck plates subjected to general corrosion is presented. The decisions about when to perform maintenance and repair on the structure are studied. Different practical scenarios are analysed and optimum repair times are proposed. The optimum repair age and intervals are defined based on the statistical analysis of operational data using the Weibull model and some assumptions about the inspection and time needed for repair. The total cost is calculated in normalized form.

10/02599 The application of integrated diagnosis database technology in safety management of oil pipeline and transferring pump units

Hu, J. *et al. Journal of Loss Prevention in the Process Industries*, 2009, 22, (6), 1025–1033.

This paper presents an integrated diagnosis database technology based on UDA method applied in safety monitoring and diagnosis of oil pipelines and transferring pump units, based on which the massive historical data of pipelines and pump units can be recorded and centralized managed. The system can redisplay the record under different running states of pipelines including fault data, and distinguish different conditions of pipeline automatically by improved ISODATA clustering method, in order to ensure the high efficiency and safety of the pipeline transportation system.

10/02600 Thermal degradation of heavy pyrolytic oil in a batch and continuous reaction system

Lee, K. H. *Journal of Analytical and Applied Pyrolysis*, 2009, 86, (2), 348–353.

Degradation of heavy pyrolytic oil obtained from a commercial rotary kiln pyrolysis plant for municipal plastic waste was conducted in batch and continuous reaction systems. The experiment was conducted by temperature programming with a 10 °C/min heating rate up to 450 °C and then maintained for a specific time at 450 °C. The product oil was sampled at different degradation temperatures with a specific interval of elapsed time of reaction. In this study, the characteristics of product oil obtained in both batch and continuous reaction systems were compared, according to degradation temperature and elapsed time at 450 °C. Raw pyrolytic oil showed a wide boiling point distribution from around 10 carbon number to about 35 and a high heating value, relative to of those of commercial oils (gasoline, kerosene, and diesel). In the two reaction systems, the characteristics of product oils were influenced by degradation temperature and elapsed time. Moreover, heavy hydrocarbons showed greater cracking at high degradation temperature and long elapsed time into light hydrocarbons as gasoline components range. Also, the continuous reaction system showed different characteristics of product oil, compared with those of the batch reaction system, such as the cumulative amount distribution, production rate, and carbon number distribution of the product oil, as a function of degradation temperature and elapsed time.

Economics, business, marketing, policy

10/02601 A real options based model and its application to China's overseas oil investment decisions

Fan, Y. and Zhu, L. *Energy Economics*, 2010, 32, (3), 627–637.

This paper applies real options theory to overseas oil investment by adding an investment–environment factor to oil-resource valuation. A real options model is developed to illustrate how an investor country (or oil company) can evaluate and compare the critical value of oil-resource investment in different countries under oil-price, exchange-rate, and investment–environment uncertainties. The aim is to establish a broad model that can be used by every oil investor country to value overseas oil resources. The model developed here can match three key elements: (1) deal with overseas investment (the effects of investment environment and exchange rates); (2) deal with oil investment (oil price, production decline rate and development cost etc.); (3) the comparability of the results from different countries (different countries' oil-investment situation can be compared by using the option value index). China's overseas oil investment is taken as an example to explain the model by calculating each oil-investee country's critical value per unit of oil reserves and examining the effect of different factors on the critical value. The results show that the model developed here can provide useful advice for China's overseas oil investment program. The research would probably also be helpful to other investor countries looking to invest in overseas oil resources.

10/02602 A SSMS model with application to the oil and gas industry

Santos-Reyes, J. and Beard, A. N. *Journal of Loss Prevention in the Process Industries*, 2009, 22, (6), 958–970.

A systemic safety management system (SSMS) model has been developed. The SSMS aims to maintain risk within an acceptable range in the operations of any organization in a coherent way. This paper presents an application of the SSMS model to an oil and gas organization. Some features of the Piper field and Piper Alpha offshore platform have been used in order to illustrate some of the characteristics of the model. It is hoped that this approach will lead not only to more effective management of safety in the oil and gas industry, but also to more effective management of safety for any organization.

10/02603 An 'Olympic' framework for a green decommissioning of an offshore oil platform

Lakhal, S. Y. *et al. Ocean & Coastal Management*, 2009, 52, (2), 113–123.

Oil and gas offshore platform and installations have a limited life of operations. When oil runs out, many terms are used to describe the situation: abandonment, removal, disposal, decommissioning, etc. Even the issue of decommissioning is now at the forefront of deep water oil drilling for many reason (the enormous costs required for disposal, the increasing number of rigs which required removal, the need to protect the marine environment, legal frameworks), there are very few published researchers studying the problem according to its different facets (legal, environmental, economical etc.). In this paper, the concept of 'Olympic' supply chain produced in an earlier study is developed to provide feedback for life-cycle offshore platforms.

10/02604 Burning clean fuel gas improves energetic efficiency

Fonseca, A. *et al. Energy Conversion and Management*, 2010, 51, (3), 498–504.

One the most critical problems faced by refineries nowadays is the continuous increasing of legislation urging emissions reductions specifically SO_2, NO_x, and particles. Therefore there is a substantial need for refineries to burn fuel gas instead of fuel oil and avoiding, if possible, the use of imported natural gas. The refinery case study presents a substantial excess of fuel gas resulting from the production of hydrogen to obtain clean flues with low sulfur. The aim of this paper is to optimize the use of the hydrogen excess with the implementation of a gas turbine with heat recovery with a feed near 28–31% of hydrogen. The cogeneration system was modelled by GateCycle and the results obtained for the simulation were considered optimistic. Considering a production of 13 MW of electrical power the overall efficiency reached a value of 76% and 22 t/h of vapour (17 MW) from a feed of 3 t/h of fuel gas (39 MW). These results allow a higher electrical power production and a consequent reduction in the emissions of SO_2 and CO_2.

10/02605 Casing collapse risk assessment and depth prediction with a neural network system approach

Salehi, S. *et al. Journal of Petroleum Science and Engineering*, 2009, 69, (1–2), 156–162.

A large carbonate oil field in Iran is suffering from severe casing collapses. 48 casing collapses have been occurred due to reservoir compaction, poro-elastic effects and corrosion. The application of neural networks for predicting casing collapses using complex multi-dimensional field data has been undertaken. This paper shows how a neural network system can be trained based on the parameters affecting casing collapse to estimate the potential of collapse of wells to be drilled as well as the current wells producing in the field. The potential use of this type of analysis is large in that it can be linked as a critical risking parameter in future field development analysis. Being able to quantify the potential for collapse of a well in the future can give management the foundation for a better financial decision making on what wells and where to drill them with the potential for the larger net return on the investment. The estimated collapse and corresponding depth could also benefit in the type of casing design and completion method to be selected as well as workover designs. Interpretation of the neural network results, together with engineering judgment, allowed us to conclude that using this method is technically feasible for predicting casing collapses in this field.

10/02606 Long term prediction of unconventional oil production

Mohr, S. H. and Evans, G. M. *Energy Policy*, 2010, 38, (1), 265–276.

Although considerable discussion surrounds unconventional oil's ability to mitigate the effects of peaking conventional oil production, very few models of unconventional oil production exist. The aim of this article was to project unconventional oil production to determine how significant its production may be. Two models were developed to predict the unconventional oil production, one model for in situ production and the other for mining the resources. Unconventional oil production is anticipated to reach between 18 and 32 Gb/y (49–88 Mb/d) in 2076–2084, before declining. If conventional oil production is at peak production then projected unconventional oil production cannot mitigate peaking of conventional oil alone.

10/02607 Russia's output revival boosts exports

Anon., *Oil and Energy Trends*, 2010, 35, (5), 3–6.

Russia's oil production rose in 2009 and output looks set to exceed 10 million barrels per day in 2010. Exports have risen as a result of this and a new crude oil stream, East Siberia – Pacific Oil Blend (ESPO), has been opened up for the Asian markets. The ESPO stream indicates a possible shift in Russian export strategy that targets the growing demand in Asia.

10/02608 Thermoeconomic analysis of SOFC-GT hybrid systems fed by liquid fuels

Santin, M. *et al. Energy*, 2010, 35, (2), 1077–1083.

In the distributed power generation market, solid oxide fuel cell–gas turbine (SOFC–GT) hybrids are an attractive option. Prototypes are being tested around the world with different types of fuel, but mainly natural gas. In this publication, a study of SOFC–GT hybrids for operation with liquid fuels is presented. Two liquid fuels were investigated, methanol and kerosene, in four layouts, taking into account different fuel processing strategies. A 500 kW class hybrid system was analysed. Web-based ThermoEconomic Modular Program (WTEMP) software, developed by the Thermochemical Power Group of the University of Genoa, was used for the thermodynamic and investment analysis. Performance was calculated based on zero-dimensional component models. The economic assessment was performed with a through-life cost analysis approach. The cost of the conventional components was calculated with WTEMP cost equations. As a final result, methanol-fuelled hybrid sources are shown to stand out for both their thermodynamic and economic performance.

Derived liquid fuels

10/02609 High porous carbon with Cu/ZnO nanoparticles made by the pyrolysis of carbon material as a catalyst for steam reforming of methanol and dimethyl ether

Kudo, S. *et al. Carbon*, 2010, 48, (4), 1186–1195.

Cu/ZnO/carbon catalysts for steam-reforming reactions were prepared by a technique designed to disperse the metals over the porous carbon. The preparation method includes the carbonization of an ion exchange resin loaded with metal cations. By containing ZnO in the resin, the agglomeration of Cu particle during the carbonization was suppressed within the carbon matrix due to the difference in the behaviour of carbonization and migration between Cu and Zn in the same ion exchange resin, and the Cu particle size was reduced. Thus, the obtained Cu3Zn1 catalyst had more than double the Cu surface area of the catalyst contained only Cu, regardless of lower Cu content. Methanol steam reforming test showed that the activity of the catalysts was positively correlated with Cu surface area. Also in dimethyl ether (DME) steam reforming reactions using the composite catalysts with γ-Al_2O_3, the catalytic activity tracked with the surface area covered by Cu. The optimized Cu/ZnO/carbon catalyst composite showed a high DME conversion of 0.87 even at the low temperature of 300 °C and with GHSV = 2000 h^{-1}, which was due to high dispersion of Cu on the micropore structure of carbon support.

10/02610 Preliminary investigation on concentrating of acetol from wood vinegar

Wang, Z. *et al. Energy Conversion and Management*, 2010, 51, (2), 346–349.

Acetol, as one of the components in biomass pyrolysis liquid, is a high value added compound for medicine synthesis. Benefit may be obtained if acetol can be extracted from the pyrolysis liquid, while the instability of acetol makes the concentrating difficult. In this paper, the concentrating of acetol from wood vinegar is preliminarily investigated, and the conditions of distillation, solvent extraction, and Na_2CO_3 effect on the concentrating result are discussed. Herein the content of acetol can be concentrated from below 4% in the raw wood vinegar to above 60%, and the number of main components reduce from over 20 to 5, while the yield of acetol is still rather low. It was found that in the organic solution distillation process, acetol can be easily concentrated from 1% to above 40%, while a further distillation of the concentrated acetol system was rather hard. The conversion of acetol in the distillation process was probably an important cause to the low yield of acetol, and a lower distillation temperature was advantageous for the concentrating of acetol.

10/02611 Thermal degradation of polyethylene into fuel oil over silica–alumina by a continuous flow reactor

Murata, M. *et al. Journal of Analytical and Applied Pyrolysis*, 2009, 86, (2), 354–359.

A continuous flow reactor was operated at 420 °C and feed rate of 0–1.5 kg h^{-1} for catalytic degradation of polyethylene (PE) over SA-1 silica–alumina in order to investigate the effect of catalyst on the reaction rate and the quantity and quality of degradation products. SA-1 was either mixed with the PE inside reactor or placed in a catalyst cage, the efficiency being slightly higher in the first case. The catalyst did not have a significant effect on the reaction rates but the volatile products clearly had lower molecular weights. More gases were produced on SA-1 compared to thermal degradation, containing higher amounts of C_4 and less amounts of C_2 compounds.

03 GASEOUS FUELS

Sources, properties, recovery, treatment

10/02612 Simulation based analysis and an application to an offshore oil and gas production system of the Natvig measures of component importance in repairable systems

Natvig, B. *et al. Reliability Engineering & System Safety*, 2009, 94, (10), 1629–1638.

In the present paper the Natvig measures of component importance for repairable systems, and its extended version are analysed for two three-component systems and a bridge system. The measures are also applied to an offshore oil and gas production system. According to the extended version of the Natvig measure a component is important if both by failing it strongly reduces the expected system uptime and by being repaired it strongly reduces the expected system downtime. The results include a study of how different distributions affect the ranking of the components. All numerical results are computed using discrete event simulation. The advanced simulation methods needed in these calculations are described in a companion paper.

Transport, storage

10/02613 Analytical solution for estimating storage efficiency of geologic sequestration of CO_2

Okwen, R. T. *et al. International Journal of Greenhouse Gas Control*, 2010, 4, (1), 102–107.

During injection of carbon dioxide (CO_2) into deep saline aquifers, the available pore volume of the aquifer may be used inefficiently, thereby decreasing the effective capacity of the repository for CO_2 storage. Storage efficiency is the fraction of the available pore space that is utilized for CO_2 storage, or, in other words, it is the ratio between the volume of stored CO_2 and the maximum available pore volume. In this study, the authors derive and present simple analytical expressions for estimating CO_2 storage efficiency under the scenario of a constant-rate injection of CO_2 into a confined, homogeneous, isotropic, saline aquifer. The expressions for storage efficiency are derived from models developed previously by other researchers describing the shape of the CO_2-brine interface. The storage efficiency of CO_2 is found to depend on three dimensionless groups, namely: (1) the residual saturation of brine after displacement by CO_2; (2) the ratio of CO_2 mobility to brine mobility; (3) a dimensionless group (which the authors call a ‘gravity factor’) that quantifies the importance of CO_2 buoyancy relative to CO_2 injection rate. In the particular case of negligible residual brine saturation and negligible buoyancy effects, the storage efficiency is approximately equal to the ratio of the CO_2 viscosity to the brine viscosity. Storage efficiency decreases as the gravity factor increases, because the buoyancy of the CO_2 causes it to occupy a thin layer at the top of the confined formation, while leaving the lower part of the aquifer under-utilized. Estimates of storage efficiency from the simple analytical expressions are in reasonable agreement with values calculated from simulations performed with more complicated multi-phase-flow simulation software. Therefore, it is suggested that the analytical expressions presented herein could be used as a simple and rapid tool to screen the technical or economic feasibility of a proposed CO_2 injection scenario.

10/02614 Detection of leak acoustic signal in buried gas pipe based on the time–frequency analysis

Kim, M.-S. and Lee, S.-K. *Journal of Loss Prevention in the Process Industries*, 2009, 22, (6), 990–994.

A time–frequency technique for locating leaks in buried gas distribution pipes involves the use of the cross-correlation on two measured acoustic signals on either side of a leak. This technique can be problematic for locating leaks in steel pipes, as the acoustic signals in these pipes are generally narrow-band and low frequency. The effectiveness of the time–frequency technique for detecting leaks in steel pipes was investigated experimentally in an earlier study. The object of this paper is to identify the characteristics of this dispersive acoustic wave through analysis of the cut-off frequency by using the time–frequency method experimentally and boundary element method theoretically for the development of an experimental tool to analyse the leak signals in steel pipe. The tool is based on experimental work and theoretical formulation of wave propagation in a fluid-filled pipe. This tool uses the time–frequency method to explain some of the features of wave propagation measurements made in gas pipes. Leak noise signals are generally passed through a time–frequency filter for detection of impulse signal related leakage.

10/02615 Mathematical modeling and simulation of pigging operation in gas and liquid pipelines

Esmaeilzadeh, F. *et al. Journal of Petroleum Science and Engineering*, 2009, 69, (1–2), 100–106.

The pigging operation is a common practice in the petroleum and gas industry. Pigging flow lines is employed for many reasons including cleaning deposits such as wax layers, the removal of liquids and condensate, the separation of products pumped one after the other in the same pipeline, measurement, and control and flow line inspection. In this paper, the mathematical modelling of the transient motion of a pig through liquid and gas pipelines is presented. For this purpose, the fluid flow equations were combined with a linear momentum equation for the pig. The nonlinear equations are solved under an unsteady state condition by the method of characteristics with a regular rectangular grid through the pipeline under appropriate initial and boundary conditions. From this simulation, the pig position, optimum flow rate in upstream flow and the time that the pig reaches the end of the pipeline are obtained. Comparison of the simulation results with the field data of liquid flow through the pipeline from KG to AG located in Iran show that the derived mathematical models are effective for the prediction of position and pig velocity under the given operational conditions of a pipeline. Similar results are also obtained for gas flow through the pipeline from Nar-1 to Nar-2 located in Iran, in comparison with the field data.

10/02616 Quick estimation of gas pipeline inventory

Ettouney, R. S. and El-Rifai, M. A. *Journal of Petroleum Science and Engineering*, 2009, 69, (1–2), 139–142.

Quick estimation of the pipeline inventory at the end of fiscal periods is common practice in companies dealing with the transmission of natural gas. The accuracy of line pack estimation depends on the accuracy of estimating the mean value of the gas density (or specific volume) which depends on composition and the distribution of pressure, temperature, and compressibility factor along the pipeline. An improved line pack estimation formula is developed for natural gas flowing in a horizontal pipeline. The derived formula takes into consideration the variation of velocity, pressure, temperature, and compressibility factor along the pipeline. Numerical results comparing the errors associated with line pack estimation on the basis of alternative approximations to the mean pressure, temperature, and compressibility factor are presented. The errors entailed on using different approximations depend on the gas composition, and the magnitude of the pressure and temperature ranges existing at the extremities of the pipe segment.

10/02617 Thermoeconomical analysis of CO_2 removal from the Corex export gas and its integration with the blast-furnace assembly and metallurgical combined heat and power (CHP) plant

Lampert, K. *et al. Energy*, 2010, 35, (2), 1188–1195.

The paper presents the possibility of integration of the Corex process, blast furnace, CO_2 removal installation and metallurgical combined heat and power (CHP) plant. Such an integration has significant advantages from the technical and environmental points of view. As the Corex export gas (after CO_2 removal) is a highly valuable reducing agent, it is proposed to use it as a reducing gas injected to the thermal reserve zone of the blast-furnace process. Such an application leads first of all to a saving of coke. Besides the reduction of the consumption of coke, also the consumption of blast, high-purity oxygen, the amount and lower heating value (LHV) of blast-furnace gas as well as many other parameters are changed. CO_2 separation is realized by physical absorption, which has been chosen and analysed as the most appropriate technology in similar applications. Higher LHV of the Corex gas obtained by CO_2 removal provides the possibility of its utilization in the gas-and-steam CHP plant. Such a possibility has been also tested by means of energy and economical analyses.

Economics, business, marketing, policy

10/02618 A generic graphical approach for simultaneous targeting and design of a gas network

Wan Alwi, S. R. *et al. Resources, Conservation and Recycling*, 2009, 53, (10), 588–591.

This paper presents a generic graphical approach for simultaneous targeting and design of a utility gas network. The approach has been effectively and interactively used to target the minimum utility gas flow rate and design a maximum nitrogen gas recovery network. A graphical tool known as the Network Allocation Diagram is introduced to assist designers to graphically visualize, explore, evolve, and systematically select networks that yield either the minimum gas targets or the minimum number of streams. Application of this approach results in a potential reduction of 33.8% fresh gas and waste gas.

10/02619 Another Caspian export scheme: but where is the gas?

Anon., *Oil and Energy Trends*, 2010, 35, (5), 7–8.

The Azerbaijan–Georgia–Romanian–Interconnect (AGRI) scheme plans to supply gas from the Caspian and Black Sea to the European Union (EU) as liquefied natural gas (LNG). The LNG would be transported to the port of Constanza in Romania, where it would be regasified and piped across the EU. While this arrangement would aid the EU in reducing its reliance on Russian gas, issues still remain about the sourcing of this gas.

10/02620 Does the European natural gas market pass the competitive benchmark of the theory of storage? Indirect tests for three major trading points

Stronzik, M. *et al. Energy Policy*, 2009, 37, (12), 5432–5439.

This paper presents the first comparative analysis of the relationship between natural gas storage utilization and price patterns at three major European trading points. Using two indirect tests, developed in earlier studies, which are applied in other commodity markets, the no arbitrage condition was imposed to model the efficiency of the natural gas market. The results reveal that while operators of European storage facilities realize seasonal arbitrage profits, substantial arbitrage potentials remain. It is suggested that the indirect approach is well suited to provide market insights for periods with limited data. It was found that overall market performance differs substantially from the competitive benchmark of the theory of storage.

10/02621 Investment in transport infrastructure, regulation, and gas–gas competition

Gasmi, F. and Oviedo, J. D. *Energy Economics*, 2010, 32, (3), 726–736.

This paper develops a simple model in which a regulated (upstream) transporter provides capacity to a marketer competing in output with an incumbent in the (downstream) gas commodity market. The equilibrium outcome of the firms' interaction in the downstream market is explicitly taken into account by the regulator when setting the transport charge. Various forms of competition in this market were considered and the corresponding optimal transport charge policies derived. Simulations were carried out that allowed a comparative welfare analysis to be performed of these transport infrastructure investment policies based on different assumptions about the intensity of the competition that prevails in the gas commodity market.

10/02622 Risk analysis based LNG facility siting standard in NFPA 59A

Raj, P. K. and Lemoff, T. *Journal of Loss Prevention in the Process Industries*, 2009, 22, (6), 820–829.

In the USA, liquefied natural gas (LNG) has the unique distinction of being the only flammable or hazardous material whose storage terminal (siting), handling and terminal operations are regulated by the federal government. These regulations are very prescriptive and inflexible in that they do not allow alternative safety mitigation considerations for LNG facility siting without applying for a special permit. The types and sizes of accidental releases to be evaluated are prescribed and no deviation is allowed. Without considering a spectrum of events, their likelihood of occurrence and the resultant consequences it is impossible to design proper mitigation actions or emergency response procedures. The benefit of knowing and preparing for a properly evaluated 'most likely event' scenario is the resultant correct application of economics, and personnel resources of emergency responders. The 2009 edition of NFPA 59A includes, in a mandatory annex, an alternative, risk-based requirements to evaluate the safety of land-based LNG facilities. DOT, in its regulations on the transportation of natural gas in interstate pipelines, requires the conduct of a 'Pipeline Integrity Management' procedure to ensure public safety from accidental gas releases from interstate pipelines. The regulations refer to this procedure as 'risk-based' even though frequencies of accidents or equipment failures are not considered. The National Association of Regulatory Utility Commissioners (NARUC) and the National Association of States Fire Marshals (NASFM) have recently passed resolutions calling on DOT (PHMSA) to initiate steps towards the development of risk-based LNG facility siting regulations. This paper discusses the risk evaluation approach incorporated into a mandatory annex in the 2009 edition of NFPA 59A and possible other methods of performing a LNG facility risk assessment. Also discussed are the parameters that society has to agree to establish an 'acceptable' level of risk. The paper indicates the risk process used in other countries, particularly in Europe. The results from the application of a risk analysis procedure to a specific case are presented. A comparison of the risk-based results with those obtained from the application of the current prescriptive requirements in NFPA 59A (or 49 CFR, part 193) is indicated. Recommendations are provided for future actions.

10/02623 Understanding the formative stage of technological innovation system development: the case of natural gas as an automotive fuel

Suurs, R. A. A. *et al. Energy Policy*, 2010, 38, (1), 419–431.

This study contributes to insights into mechanisms that influence the successes and failures of emerging energy technologies. It is assumed that for an emerging technology to fruitfully develop, it should be fostered by a technological innovation system (TIS), which is the network of actors, institutions and technologies in which it is embedded. For an emerging technology a TIS has yet to be built up. This research focuses on the dynamics of this build-up process by mapping the development of seven key activities: so-called system functions. The main contribution revolves around the notion of cumulative causation, or the phenomenon that the build-up of a TIS accelerates due to system functions reinforcing each other over time. As an empirical basis, an analysis is provided of the historical development of the TIS around automotive natural gas technology in the Netherlands (1970–2007). The results show that this TIS undergoes a gradual build-up in the 1970s, followed by a breakdown in the 1980s and, again, a build-up from 2000 to 2007. It is shown that underlying these trends are different forms of cumulative causation, here called motors of innovation. The study provides strategic insights for practitioners that aspire to support such motors of innovation.

Derived gaseous fuels

10/02624 Continuous synthesis of surface-modified zinc oxide nanoparticles in supercritical methanol

Veriansyah, B. *et al. The Journal of Supercritical Fluids*, 2010, 52, (1), 76–83.

Continuous synthesis of surface-modified zinc oxide (ZnO) nanoparticles was examined using surface modifiers (oleic acid and decanoic acid) in supercritical methanol at 400 °C, 30 MPa and a residence time of ~40 s. Wide angle X-ray diffraction analysis revealed that the surface-modified nanoparticles retained ZnO crystalline structure. Scanning electron microscopy and transmission electron microscopy showed that the surface modifiers changed drastically the size and morphology of the ZnO nanoparticles. When the molar ratio of oleic acid to Zn precursor ratio was 30, 10 nm size particles with low degree of aggregation were produced. The surface-modified ZnO nanoparticles had higher BET surface areas (29–36 m^2/g) compared to unmodified ZnO particles synthesized in supercritical water (0.7 m^2/g). Fourier transform infrared and thermogravimetric analysis indicated that aliphatic, carboxylate and hydroxyl groups were chemically attached on the surface of ZnO nanoparticles. Long-term (80 days) dispersion test using ultraviolet transmittance showed that the surface-modified ZnO particles had enhanced dispersion stability in ethylene glycol.

10/02625 Experimental studies on molar distribution of CO/CO_2 and CO/H_2 along the length of downdraft wood gasifier

Ratnadhariya, J. K. and Channiwala, S. A. *Energy Conversion and Management*, 2010, 51, (3), 452–458.

Experimental studies on molar distribution of CO/CO_2 and CO/H_2 along the length of downdraft wood gasifier are reported in this paper. Sixteen numbers of special probes have been prepared and installed in various zones of the laboratory scale downdraft wood gasifier for generating data through exhaustive measurements of simultaneous concentration and temperature profiles along the length of gasifier using four different woody biomass materials in different shapes and sizes as a feedstock. Eight molar distribution for CO/CO_2 and seven for CO/H_2 have been derived using these data of concentration and temperature profiles along the length of gasifier, while best molar distribution for both was decided based on comparison of their average absolute and bias errors and validated with present and published experimental data points of other biomass also. Both CO/CO_2 and CO/H_2 distribution proposed in present work are found very close to measured values and thereby establish its acceptability.

10/02626 Preferences of coastal zone user groups regarding the siting of offshore wind farms

Ladenburg, J. and Dubgaard, A. *Ocean & Coastal Management*, 2009, 52, (5), 233–242.

Offshore wind power has a large potential as a vast resource for delivering clean and abundant energy on a global scale. However, the siting of offshore wind farms in the coastal zone has negative effects on the seascape. This might be particularly evident in the case if offshore wind farms are located close to areas with recreational activities in the coastal zone. Extending the analysis from a previous investigation of the preference for reducing visual impacts from offshore wind farms, the present paper utilizes the same sample representing the Danish population. Based on the stated preferences from a Choice Experiment in a mail survey the preferences for reducing visual disamenities from offshore wind farms among different types of coastal zone users are compared to the preferences of less frequent users of the coastal zone. The results strongly indicate that in addition people who can see offshore wind farms from their residence, anglers and recreational boaters, i.e. users of the coastal zone, significantly perceive the visual impacts to be more negative compared to people who do not use the coastal area for those specific purposes. Furthermore, the results also indicate that respondents who visit the beach on a frequent basis also have stronger preferences for reducing the visual disamenities, when compared to less frequent visitors. As a consequence, the specific users and frequent visitors of the coastal zone are willing to pay approximately twice as much to have future offshore wind farms moved further away from the coast, when compared to less frequent users and visitors. These results display that, given the wind farms are not located at relative large distance from the shore, the recreational value of the coastal use is potentially jeopardized by visual impacts from offshore wind farms. From an energy planner's point of view, these results are noteworthy, as they – everything else being equal – point towards that potential gains in capital cost (investment, construction and running costs) by locating offshore wind farms at relative close distances from the shore might be outweighed by the visual disamenity costs in coastal areas with a large recreational activity. As such, the optimal location, i.e. distance from the shore, of offshore wind farms might be closer to the coast in areas with little recreational activities compared to coastal areas with a higher level of recreational activities.

10/02627 Pretreatment of agricultural residues for co-gasification via torrefaction

Deng, J. *et al. Journal of Analytical and Applied Pyrolysis*, 2009, 86, (2), 331–337.

Torrefaction is a main pretreatment technology for improving the properties of agricultural biomass in order to deal with such problems as high bulk volume, high moisture content and poor grindability. Two typical agricultural residues, rice straw and rape stalk were torrefied in a vertical reactor at 200 °C, 250 °C and 300 °C for 30 min, under inert atmosphere. The product distribution profiles of solid, liquid and gases were obtained. The grindability of the torrefied biomass was evaluated by the particle size distribution after being milled in a ball mill. It was found that temperature strongly affected the torrefied biomass and the type of feedstock influenced the conversion rate due to the different volatile content in raw biomass. An increase of torrefaction temperature leads to a decrease in solid bio-char yield and an increasing yield in the volatile matters including liquid and non-condensable gases. The maximum increase of the heating value of the torrefied residue compared with the raw material is 17% for the rice straw and 15% for the rape stalk, respectively. On the other hand, the torrefied residues are liable to be pulverized. A kinetic study on the generation of main non-condensable gases was accomplished, which shows that the gases are formed through parallel independent first-order reactions. The kinetic characteristic parameters for the generation of each gas were determined. A novel method which combined torrefaction with co-gasification to improve the efficiency of biomass utilization is promising.

10/02628 Recent developments in dry hot syngas cleaning processes

Sharma, S. D. *et al. Fuel*, 2010, 89, (4), 817–826.

The dry hot syngas cleaning process appears to be potentially more efficient and cleaner than the proven wet cleaning or semi-wet cleaning processes but it is still far from commercialization. There are several technological barriers responsible such as poor availability factor, degeneration of sorbent and several stages of separation. This paper summarizes the reported current status of dry hot cleaning of syngas from coal gasification processes along with the shortcomings of reporting of dry hot syngas cleaning performance results. The paper also proposes and discusses a rational method of performance reporting, a novel pulse less filtration concept and a system to prevent failure of filter elements.

LNG

10/02629 A numerical simulation model of cyclic hardening behavior of AC4C-T6 for LNG cargo pump using finite element analysis

Lee, J. H. *et al. Journal of Loss Prevention in the Process Industries*, 2009, 22, (6), 889–896.

This paper is concerned with the evaluation of cyclic hardening models within the stress–strain behaviour of aluminium alloy AC4C-T6 that can be used to LNG cargo pump operating in cryogenic temperature. To insure the strength assessment of LNG cargo pump, material model of cyclic hardening and plasticity for aluminium alloy AC4C-T6 is investigated through finite element analysis (FEA) with various hardening options including linear and non-linear hardening, isotropic and kinematic hardening, and combined hardening model. Monotonic tensile and cyclic tensile experiments for AC4C-T6 alloy were performed at room temperature and temperature of −165 °C. Parameters of each hardening model are obtained from the experimental data; thus five hardening models are numerically simulated thereafter. Appropriate hardening models which describe the cyclic stress–strain relationship are investigated through the simulations of cyclic hardening behaviour by FEA. In order to verify the predicted behaviour of cyclic hardening obtained by FEA, the results of FEA and those measured by experiments are compared.

10/02630 A policy study examining the use of imported LNG for gas-fired power generation on the southeast coast of China

Li, Y. and Bai, F. *Energy Policy*, 2010, 38, (2), 896–901.

Since China's energy demand is growing quickly, speeding up the development of natural gas is an important substitute and supplement for coal and oil. The development of the natural gas market in many developing countries has demonstrated that the success of the whole project hinges upon the success of gas-fired power generation.

However, under the current energy pricing system in China, the advantages of gas-fired power plants, such as low investment costs and high efficiency, have not been able to offset the low price of coal. The gas-fired power plants, both at downstream of the liquefied natural gas (LNG) industry and upstream of the power sector, are faced with a dilemma. In order to solve the problems facing gas-fired power projects while providing policy guidance for the future development of gas-fired power projects, the policy of gas-fired power generation using imported LNG on the southeastern coast of China was examined. This study aims to identify the position of the national energy strategy that China should import some LNG from the other countries, to guide the development of energy policy in this region, and to formulate some clear policy measures.

10/02631 COOLCEP (cool clean efficient power): a novel CO_2-capturing oxy-fuel power system with LNG (liquefied natural gas) coldness energy utilization

Zhang, N. *et al. Energy*, 2010, 35, (2), 1200–1210.

A novel liquefied natural gas (LNG) fuelled power plant is proposed, which has virtually zero CO_2 and other emissions and a high efficiency. The plant operates as a subcritical CO_2 Rankine-like cycle. Beside the power generation, the system provides refrigeration in the CO_2 subcritical evaporation process, thus it is a cogeneration system with two valued products. By coupling with the LNG evaporation system as the cycle cold sink, the cycle condensation process can be achieved at a temperature much lower than ambient, and high-pressure liquid CO_2 can be withdrawn from the cycle without consuming additional power. Two system variants are analysed and compared, COOLCEP-S and COOLCEP-C. In the COOLCEP-S cycle configuration, the working fluid in the main turbine expands only to the CO_2 condensation pressure; in the COOLCEP-C cycle configuration, the turbine working fluid expands to a much lower pressure (near-ambient) to produce more power. The effects of some key parameters, the turbine inlet temperature and the backpressure, on the systems' performance are investigated. It was found that at the turbine inlet temperature of 900 °C, the energy efficiency of the COOLCEP-S system reaches 59%, which is higher than the 52% of the COOLCEP-C one. The capital investment cost of the economically optimized plant is estimated to be about 750 EUR/kWe and the payback period is about 8–9 years including the construction period, and the cost of electricity is estimated to be 0.031–0.034 EUR/kWh.

10/02632 Quantification of source-level turbulence during LNG spills onto a water pond

Gavelli, F. *et al. Journal of Loss Prevention in the Process Industries*, 2009, 22, (6), 809–819.

The use of computational fluid dynamics (CFD) models to simulate LNG vapour dispersion scenarios has been growing steadily over the last few years, with applications to LNG spills on land as well as on water. Before a CFD model may be used to predict the vapour dispersion hazard distances for a hypothetical LNG spill scenario, it is necessary for the model to be validated with respect to relevant experimental data. As part of a joint-industry project aimed at validating the CFD methodology, the LNG vapour source term, including the turbulence level associated with the evaporation process vapours was quantified for one of the Falcon tests. This paper presents the method that was used to quantify the turbulent intensity of evaporating LNG, by analysing the video images of one of the Falcon tests, which involved LNG spills onto a water pond. The measured rate of LNG pool growth and spreading and the quantified turbulence intensity that were obtained from the image analysis were used as the LNG vapour source term in the CFD model to simulate the Falcon-1 LNG spill test. Several CFD simulations were performed, using a vaporization flux of 0.127 $kg/m^2 s$, radial and outward spreading velocities of 1.53 and 0.55 m/s respectively, and a range of turbulence kinetic energy values between 2.9 and 28.8 m^2/s^2. The resulting growth and spread of the vapour cloud within the impounded area and outside of it were found to match the observed behaviour and the experimental measured data. The results of the analysis presented in this paper demonstrate that a detailed and accurate definition of the LNG vapour source term is critical in order for any vapour cloud dispersion simulation to provide useful and reliable results.

10/02633 Use of water spray curtain to disperse LNG vapor clouds

Rana, M. A. *et al. Journal of Loss Prevention in the Process Industries*, 2010, 23, (1), 77–88.

Effective safety measures to prevent and mitigate the consequences of an accidental release of flammable LNG are critical. Water spray curtain is currently recognized as an effective technique to control and mitigate various hazards in the industries. It has been used to absorb, dilute and disperse both toxic and flammable vapour cloud. It is also used as protection against heat radiation, in case of fighting vapour cloud fire. Water curtain has also been considered as one of the most economic and promising LNG vapour cloud control techniques. Water curtains are expected to enhance LNG vapour cloud dispersion mainly through mechanical effects, dilution, and thermal effects. The actual phenomena involved in LNG vapour and water curtain interaction were not clearly established from previous research. LNG spill experiments have been performed at the Brayton Fire Training Field at Texas A&M University (TAMU) to understand the effect of water curtain in controlling and dispersing LNG vapour cloud. This paper summarizes experimental methodology and presents data from two water curtain tests. The analysis of the test results are also presented to identify the effectiveness of these two types of water spray curtains in enhancing the LNG vapour cloud dispersion.

Hydrogen generation and storage

10/02634 Advances in hydrogen production by thermochemical water decomposition: a review

Rosen, M. A. *Energy*, 2010, 35, (2), 1068–1076.

Hydrogen demand as an energy currency is anticipated to rise significantly in the future, with the emergence of a hydrogen economy. Hydrogen production is a key component of a hydrogen economy. Several production processes are commercially available, while others are under development including thermochemical water decomposition, which has numerous advantages over other hydrogen production processes. Recent advances in hydrogen production by thermochemical water decomposition are reviewed here. Hydrogen production from non-fossil energy sources such as nuclear and solar is emphasized, as are efforts to lower the temperatures required in thermochemical cycles so as to expand the range of potential heat supplies. Limiting efficiencies are explained and the need to apply exergy analysis is illustrated. The copper–chlorine thermochemical cycle is considered as a case study. It is concluded that developments of improved processes for hydrogen production via thermochemical water decomposition are likely to continue, thermochemical hydrogen production using such non-fossil energy will likely become commercial, and improved efficiencies are expected to be obtained with advanced methodologies like exergy analysis. Although numerous advances have been made on sulphur–iodine cycles, the copper–chlorine cycle has significant potential due to its requirement for process heat at lower temperatures than most other thermochemical processes.

10/02635 Biological hydrogen production from sterilized sewage sludge by anaerobic self-fermentation

Xiao, B. and Liu, J. *Journal of Hazardous Materials*, 2009, 168, (1), 163–167.

Due to richness in proteins and carbohydrates, the sewage sludge produced from the wastewater treatment processes is becoming a potential substrate for biological hydrogen production. In this study, sterilized sludge was employed to produce hydrogen by batch anaerobic self-fermentation without any extra-feeds and extra-seeds. Sterilization can screen hydrogen-producing microorganisms from sludge microflora and release organic materials from microbial cells of sludge. Experimental results suggested that sterilization could accelerate and increase the hydrogen production of sewage sludge in the anaerobic self-fermentation, and the biogas did not contain methane. The hydrogen yield was increased from 0.35 mL H_2/g VS (raw sludge) to 16.26 mL H_2/g VS (sterilized sludge). Although sterilization could fully inhibit the activity of methanogens in the sludge, the hydrogen consumption still occurred in the anaerobic self-fermentation of sterilized sludge due to the existence of other hydrogen-consuming actions. The decrease of pH in the anaerobic self-fermentation of sterilized sludge was very lower (from 6.81 to 6.56) because NH_4^+ produced by degradation of proteins could neutralize organic acids produced in the process. The soluble chemical oxygen demand (SCOD) increase of sterilized sludge was higher than that of raw sludge. Volatile fatty acids (VFA) were the important by-products and acetate was the major composition. The hydrogen fermentation of carbohydrates was the major source of hydrogen production.

10/02636 Hydrogen production from biomass tar by catalytic steam reforming

Yoon, S. Y. *et al. Energy Conversion and Management*, 2010, 51, (1), 42–47.

The catalytic steam reforming of model biomass tar, toluene being a major component, was performed at various conditions of temperature, steam injection rate, catalyst size, and space time. Two kinds of nickel-based commercial catalyst, the Katalco 46–3Q and the Katalco 46–6Q, were evaluated and compared with dolomite catalyst. Production of hydrogen generally increased with reaction temperature, steam injection rate and space time and decreased with catalyst size. In particular, zirconia-promoted nickel-based catalyst, Katalco 46–6Q, showed a higher tar conversion efficiency and shows 100% conversion even relatively lower temperature conditions of 600 °C. Apparent activation energy was estimated to 94 and 57 kJ/mol for dolomite and nickel-based catalyst respectively.

10/02637 Hydrogen production from the monomeric sugars hydrolyzed from hemicellulose by *Enterobacter aerogenes*

Ren, Y. *et al. Renewable Energy*, 2009, 34, (12), 2774–2779.

Relatively large percentages of xylose with glucose, arabinose, mannose, galactose and rhamnose constitute the hydrolysis products of hemicellulose. In this paper, hydrogen production performance of facultative anaerobe (*Enterobacter aerogenes*) has been investigated from these different monomeric sugars except glucose. It was shown that the stereoisomers of mannose and galactose were more effective for hydrogen production than those of xylose and arabinose. The substrate of 5 g/l xylose resulted in a relative high level of hydrogen yield (73.8 mmol/l), hydrogen production efficiency (2.2 mol/mol) and a maximum hydrogen production rate (249 ml/l/h). The hydrogen yield, hydrogen production efficiency and the maximum hydrogen production rate reached 104 mmol/l, 2.35 mol/mol and 290 ml/l/h, respectively, on a substrate of 10 g/l galactose. The hydrogen yields and the maximum hydrogen production rates increased with an increase of mannose concentrations and reached 119 mmol/l and 518 ml/l/h on the culture of 25 g/l mannose. However, rhamnose was a relative poor carbon resource for *E. aerogenes* to produce hydrogen, from which the hydrogen yield and hydrogen production efficiency were about one half of that from the mannose substrate. *E. aerogenes* was found to be a promising strain for hydrogen production from hydrolysis products of hemicellulose.

10/02638 Modeling of transient hydrogen permeation process across a palladium membrane

Chen, W.-H. and Chiu, I.-H. *Applied Energy*, 2010, 87, (3), 1023–1032.

Transient mass transfer processes of hydrogen permeating through a Pd membrane are modelled to aid in predicting the hydrogen transport behaviour. The model is established in terms of the quasi-steady time and the steady permeation rate. Meanwhile, four important parameters are considered; they are the permeation lag time, the initial permeation rate, the concave up period and the concave down period. A unit step function is embedded in the model to account for the effect of the hydrogen permeation lag at a lower pressure difference. Corresponding to the lower, the moderate and the higher pressure differences (i.e. 3, 5 and 8 atm), though the hydrogen permeation undergoes a three-stage, a two-stage and a one-stage processes, respectively, these processes can be predicted well by an arc tangential function. By introducing an adjusting parameter in the arc tangential function, there exists an optimal value of the adjusting parameter when the pressure difference is lower. In regard to the moderate and higher pressure differences, the predictions agree with experiments well if the adjusting parameter is sufficiently large. Physically, the unit step function is used to account for the controlling mechanisms of hydrogen diffusion toward the membrane and the spillover of the hydrogen across the membrane. The initial jump parameter represents the rapid response of the initial hydrogen permeation. The adjusting parameter can be used to describe the relative importance of the concave up and the concave down periods.

10/02639 Preparation and application of sodium borohydride composites for portable hydrogen production

Chen, Y. and Kim, H. *Energy*, 2010, 35, (2), 960–963.

Novel composites consisting of cobalt–boron (CoB) catalyst and sodium borohydride ($NaBH_4$) implantation in polymers (polyethylene glycol (PEG) or sodium alginate) were prepared for portable hydrogen production. The CoB catalyst was synthesized by the reduction of cobalt salt in $NaBH_4$ solution followed by heat treatment in nitrogen atmosphere. The catalyst was embedded in PEG gel or alginate beads and $NaBH_4$ was directly added in PEG–dimethylformamide (DMF) gel and adsorbed in alginate beads. It is noted that the composites prepared are stable in dry air and can be easily used for hydrogen production. A rate of hydrogen production of 750 ml $\text{min}^{-1}\,\text{g}^{-1}$ was reached when simply putting the composites into pure water. The humidified pure hydrogen can be used conveniently for fuel cells.

10/02640 Promoted hydrogen generation from ammonia borane aqueous solution using cobalt–molybdenum–boron/nickel foam catalyst

Dai, H.-B. *et al. Journal of Power Sources*, 2010, 195, (1), 307–312.

Ammonia borane (AB) is an intriguing molecular crystal with extremely high hydrogen density. This study, by using a modified electroless plating method, prepared a robust supported cobalt–molybdenum–boron (Co–Mo–B)/nickel (Ni) foam catalyst that can effectively promote the hydrogen release from AB aqueous solution at ambient temperatures. The catalytic activity of the catalyst towards the hydrolysis reaction of AB can be further improved by appropriate calcination treatment. In an effort to understand the effect of calcination treatment on the catalytic activity of the catalyst, combined structural/phase analyses of the series of catalyst samples have been undertaken. Using the catalyst that is calcined at optimized condition, a detailed study of the catalytic hydrolysis kinetics of AB was carried out. It was found that the hydrolysis of AB in the presence of Co–Mo–B/Ni foam catalyst follows first-order kinetics with respect to AB concentration and catalyst amount, respectively. The apparent activation energy of the catalysed hydrolysis reaction is determined to be 44.3 kJ mol^{-1}, which compares favourably with the literature results for using other non-noble transition metal catalysts.

10/02641 Risk identification and control of stationary high-pressure hydrogen storage vessels

Xu, P. *et al. Journal of Loss Prevention in the Process Industries*, 2009, 22, (6), 950–953.

The number of hydrogen fuelling stations is steadily growing as the number of hydrogen-fuelled vehicles increases. Stationary high-pressure hydrogen storage vessels are key equipment in hydrogen fuelling station. The safety of these vessels should be first considered during the design of hydrogen infrastructure because the vessel failure will cause huge damage and losses. This paper analyses the potential hazards in these vessels. Based on the risk identification, it is proposed that risks can be mitigated and controlled by taking various measures, such as optimizing vessel structure, correct selection of materials, mitigation of ignition sources, on-line safety monitoring, safe operation and management. Furthermore, it was shown that multi-layered stationary hydrogen storage vessels, which were recently developed in the People's Republic of China, are safe in operation.

10/02642 Solar hydrogen: fuel of the near future

Pagliaro, M. *et al. Energy & Environmental Science*, 2010, 3, (3), 279–287.

Renewable hydrogen produced using solar energy to split water is perhaps the energy fuel of the future. Accelerated innovation in both major domains of solar energy (photovoltaics and concentrated solar power) has resulted in a rapid reduction in solar electricity costs, opening the route to a number of practical applications using solar hydrogen. Referring to several examples, as well as to new technologies, this paper provides insight into this important energy source.

04 BY-PRODUCTS RELATED TO FUELS

10/02643 Adsorption of herbicides on coal fly ash from aqueous solutions

Singh, N. *Journal of Hazardous Materials*, 2009, 168, (1), 233–237.

Development of low cost adsorbent for pesticide retention is an important area of research in environmental sciences. The present study reports the sorption potential of coal fly ash, a waste from power stations, for removal of metribuzin, metolachlor and atrazine from water. Batch sorption method was used to study the sorption of herbicides from water. The amount of herbicides sorbed increased with increase in the amount of fly ash in the suspension. The maximum capacity of the fly ash to adsorb metribuzin, metolachlor and atrazine was found to be 0.20, 0.28 and 0.38 mg/g by Freundlich equation and 0.56, 1.0 and 3.33 mg/g by Langmuir equation. Freundlich adsorption equation better explained the results of herbicides sorption in fly ash as regression coefficient (R^2) values were higher from Freundlich equation than the Langmuir equation. Adsorption isotherms were L-type suggesting that the herbicide sorption efficiency of fly ash depend on the initial concentration of herbicide in the solution and maximum removal of herbicide was observed at concentrations less than 10 µg/ml. The results of this study have implications in using the fly ash for removal of these herbicides from industrial and agricultural waste water and can find use as a material in the preparation of biobeds to minimize environmental contamination from pesticide use.

10/02644 Adsorption of phenol by activated carbon: influence of activation methods and solution pH

Beker, U. *et al. Energy Conversion and Management*, 2010, 51, (2), 235–240.

Cherry stone based activated carbon derived from a canning industry was evaluated for its ability to remove phenol from an aqueous solution in a batch process. A comparative adsorption on the uptake of phenol by using commercial activated carbon (Chemviron CPG-LF), and two non-functional commercial polymeric adsorbents (MN-200 and XAD-2) containing a styrene–divinylbenzene macroporous hyperreticulated network have been also examined. Equilibrium studies were conducted in 25 mg L^{-1} initial phenol concentrations, 6.5–9 solution pH and at temperature of 30 °C. The experimental data were analysed by the

Langmuir and Freundlich isotherm models. Besides, the cherry stone based activated carbons were carried out by using zinc chloride and KOH activation agents at different chemical ratios (activating agent/precursor), to develop carbons with well-developed porosity. The cherry stone activated carbon prepared using KOH as a chemical agent showed a high surface area. According to the results, activated carbons had excellent adsorptive characteristics in comparison with polymeric sorbents and commercial activated carbon for the phenol removal from the aqueous solutions.

10/02645 Effect of rosin to coal-tar pitch on carbonization behavior and optical texture of resultant semi-cokes

Lin, Q. *et al. Journal of Analytical and Applied Pyrolysis*, 2009, 86, (1), 8–13.

Coal-tar pitch was modified with rosin, and carbonization behaviour of the modified pitches and optical texture of resultant semi-cokes were studied in this paper. The carbonization behaviour was studied by thermogravimetric analysis (TGA) and Fourier transform infrared (FTIR) spectroscopy techniques, respectively. The optical texture of resultant semi-cokes was characterized by polarized-light microscopy. The results show that there are marked differences in the carbonization behaviour of coal-tar pitch and the modified pitches. The modification results in a small decrease in carbonization yield by 1.2–3.2% when rosin content is kept at 5–15 wt.% of coal-tar pitch. The modified pitches have functional groups of cycloparaffin, double bonds, and carboxyl group, which gradually disappear and aromatization degree increases with increasing heat treatment temperature. Moreover, the modification contributes to a notable improvement in the optical texture of resultant semi-cokes which varies from coarse-grained mosaics to domains.

10/02646 Factors affecting the suitability of fly ash as source material for geopolymers

Diaz, E. I. *et al. Fuel*, 2010, 89, (5), 992–996.

The suitability of fly ash stock piles for geopolymer manufacturing was studied. The results of chemical analyses, X-ray diffraction (XRD) and particle size distribution (PSD) of five sources of fly ash obtained from coal-fired power generating plants in the US are presented. Geopolymer paste and concrete specimens were prepared from each stock pile. The specimens were subjected to an array of chemical and mechanical tests including XRD, RAMAN spectroscopy, setting time and compressive strength. A correlation study was undertaken comparing the fly ash precursor chemical and crystallographic compositions as well as particle size distribution, with the mechanical and chemical characteristics of the resulting geopolymer. Factors inherent to the fly ash stockpile such as particle size distribution, degree of vitrification and location of the glass diffraction maximum were found to play an important role in the fresh and hardened properties of the resulting geopolymer.

10/02647 Material and structural characterization of alkali activated low-calcium brown coal fly ash

Škvára, F. *et al. Journal of Hazardous Materials*, 2009, 168, (2–3), 711–720.

The waste low-calcium Czech brown coal fly ash represents a considerable environmental burden due to the quantities produced and the potentially high content of leachable heavy metals. The heterogeneous microstucture of the geopolymer M*n* [–(Si–O) *z*–Al–O]$n \cdot w$H$_2$O, that forms during the alkaline activation, was examined by means of microcalorimetry, XRD, TGA, DSC, MIP, FTIR, NMR MAS (^{29}Si, ^{27}Al, ^{23}Na), ESEM, EDS, and EBSD. The leaching of heavy metals and the evolution of compressive strength were also monitored. The analysis of raw fly ash identified a number of different morphologies, unequal distribution of elements, Fe-rich rim, high internal porosity, and minor crystalline phases of mullite and quartz. Microcalorimetry revealed exothermic reactions with dependence on the activator alkalinity. The activation energy of the geopolymerization process was determined as 86.2 kJ/mol. The X-ray diffraction analysis revealed no additional crystalline phases associated with geopolymer formation. Over several weeks, the ^{29}Si NMR spectrum testified a high degree of polymerization and Al penetration into the SiO$_4$ tetrahedra. The ^{23}Na NMR MAS spectrum hypothesized that sodium is bound in the form of Na(H$_2$O)*n* rather than Na$^+$, thus causing efflorescence in a moisture-gradient environment. As and Cr^{6+} are weakly bonded in the geopolymer matrix, while excellent immobilization of Zn^{2+}, Cu^{2+}, Cd^{2+}, and Cr^{3+} are reported.

10/02648 Quantitative evaluation of minerals in fly ashes of biomass, coal and biomass–coal mixture derived from circulating fluidised bed combustion technology

Koukouzas, N. *et al. Journal of Hazardous Materials*, 2009, 169, (1–3), 100–107.

The chemical and mineralogical composition of fly ash samples collected from laboratory scale circulating fluidized bed (CFB) combustion facility have been investigated. Three fly ashes were collected from the second cyclone in a 50 kW laboratory scale boiler, after the combustion of different solid fuels. Characterization of the fly ash samples was conducted by means of X-ray fluorescence (XRF), X-ray diffraction (XRD) and scanning electron microscopy (SEM). Quantitative analysis of the crystalline (mineral) and amorphous phases in each ash sample was carried out using the Rietveld-based Siroquant system, with an added spike of ZnO to evaluate the amorphous content. SiO$_2$ is the dominant oxide in the fly ashes, with CaO, Al$_2$O$_3$ and Fe$_2$O$_3$ also present in significant proportions. XRD results show that all three fly ashes contain quartz, anhydrite, hematite, illite and amorphous phases. The minerals calcite, feldspar, lime and periclase are present in ashes derived from Polish coal and/or woodchips. Ash from FBC combustion of a Greek lignite contains abundant illite, whereas illite is present only in minor proportions in the other ash samples.

10/02649 Utilization of fly ash with silica fume and properties of Portland cement–fly ash–silica fume concrete

Nochaiya, T. *et al. Fuel*, 2010, 89, (3), 768–774.

This paper reports the normal consistency, setting time, workability and compressive strength results of Portland cement–fly ash–silica fume systems. The results show that water requirement for normal consistency was found to increase with increasing SF content while a decrease in initial setting time was found. Workability, measured in term of slump, was found to decrease with silica fume content (compared to blends without silica fume). However, it must be noted that despite the reduction in the slump values, the workability of Portland cement–fly ash–silica fume concrete in most cases remained higher than that of the Portland cement control concrete. Furthermore, the utilization of silica fume with fly ash was found to increase the compressive strength of concrete at early ages (pre 28 days) up to 145% with the highest strength obtained when silica fume was used at 10 wt%. Moreover, scanning electron micrographs show that utilization of fly ash with silica fume resulted in a much denser microstructure, thereby leading to an increase in compressive strength.

10/02650 Workability and strength of lignite bottom ash geopolymer mortar

Sathonsaowaphak, A. *et al. Journal of Hazardous Materials*, 2009, 168, (1), 44–50.

In this paper, the waste lignite bottom ash from power station was used as a source material for making geopolymer. Sodium silicate and sodium hydroxide (NaOH) were used as liquid for the mixture and heat curing was used to activate the geopolymerization. The fineness of bottom ash, the liquid alkaline/ash ratio, the sodium silicate/NaOH ratio and the NaOH concentration were studied. The effects of the additions of water, NaOH and napthalene-based superplasticizer on the workability and strength of the geopolymer mortar were also studied. Relatively high strength geopolymer mortars of 24.0–58.0 MPa were obtained with the use of ground bottom ash with 3% retained on sieve no. 325 and mean particle size of 15.7 µm, using liquid alkaline/ash ratios of 0.429–0.709, the sodium silicate/NaOH ratios of 0.67–1.5 and 7.5–12.5 M NaOH. The incorporation of water improved the workability of geopolymer mortar more effectively than the use of napthalene-based superplasticizer with similar slight reduction in strengths. The addition of NaOH solution slightly improves the workability of the mix while maintaining the strength of the geopolymer mortars.

05 NUCLEAR FUELS

Scientific, technical

10/02651 A trajectory tracking genetic fuzzy logic controller for nuclear research reactors

Coban, R. and Can, B. *Energy Conversion and Management*, 2010, 51, (3), 587–593.

In this study, a trajectory tracking genetic fuzzy logic controller was designed for research reactors. Membership functions and action weights of the fuzzy controller were optimally determined by genetic algorithms. The behaviour of the controller was tested for various initial and desired power levels as well as under disturbance. It was seen that the controller could control the system successfully under all conditions within the acceptable error tolerance.

10/02652 Analysis of tensile deformation and failure in austenitic stainless steels: part I – temperature dependence

Kim, J. W. and Byun, T.-S. *Journal of Nuclear Materials*, 2010, 396, (1), 1–9.

This paper describes the temperature dependence of deformation and failure behaviours in austenitic stainless steels (annealed 304, 316, 316LN, and 20% cold-worked 316LN) in terms of equivalent true stress–true strain curves. The true stress–true strain curves up to the final fracture were calculated from tensile test data obtained at −150 to 450 °C using an iterative finite element method. Analysis was largely focused on the necking and fracture: key parameters such as the strain hardening rate, equivalent fracture stress, fracture strain, and tensile fracture energy were evaluated, and their temperature dependencies were investigated. It was shown that a significantly high strain hardening rate was retained during unstable deformation although overall strain hardening rate beyond the onset of necking was lower than that of the uniform deformation. The fracture stress and energy decreased with temperature up to 200 °C and were nearly saturated as the temperature came close to the maximum test temperature 450 °C. The fracture strain had a maximum at −50 to 20 °C before decreasing with temperature. It was explained that these temperature dependencies of fracture properties were associated with a change in the dominant strain hardening mechanism with test temperature. Also, it was seen that the pre-straining of material has little effect on the strain hardening rate during necking deformation and on fracture properties.

10/02653 Analysis of tensile deformation and failure in austenitic stainless steels: part II – irradiation dose dependence

Kim, J. W. and Byun, T. S. *Journal of Nuclear Materials*, 2010, 396, (1), 10–19.

Irradiation effects on the stable and unstable deformation and fracture behaviour of austenitic stainless steels (SSs) have been studied in detail based on the equivalent true stress versus true strain curves. An iterative finite element simulation technique was used to obtain the equivalent true stress–true strain data from experimental tensile curves. The simulation result showed that the austenitic stainless steels retained high strain hardening rate during unstable deformation even after significant irradiation. The strain hardening rate was independent of irradiation dose up to the initiation of a localized necking. Similarly, the equivalent fracture stress was nearly independent of dose before the damage (embrittlement) mechanism changed. The fracture strain and tensile fracture energy decreased with dose mostly in the low dose range $<\sim 2$ dpa and reached nearly saturation values at higher doses. It was also found that the fracture properties for EC316LN SS were less sensitive to irradiation than those for 316 SS, although their uniform tensile properties showed almost the same dose dependencies. It was confirmed that the dose dependence of tensile fracture properties evaluated by the linear approximation model for nominal stress was accurate enough for practical use without elaborate calculations.

10/02654 Averaging methods of the gap heat transfer coefficients and the loss form coefficients of nuclear reactor cores loaded with different fuel bundles

Sekhri, A. *et al. Annals of Nuclear Energy*, 2009, 36, (10), 1527–1535.

When performing transient analysis in heterogeneous nuclear reactors loaded with different types of fuel bundles is necessary to model the reactor core by a few representative fuel elements with average properties of a region containing a large number of fuel elements. The properties of these representative fuel bundles are obtained by averaging the thermal–hydraulic properties of the fuel elements contained in each region. This paper studies the different ways to perform the averaging of the thermal–hydraulic properties that can have an influence on the transient results for licence purposes. Also this study considers the influence of the different averaging methods on the peak clad temperature evolution for a loss of coolant accident, and on the critical power ratio in the hot channels for a turbine trip transient without bypass credit.

10/02655 Comparative study of fuel burn-up and radioactive inventory for proliferation and proliferation resistant fuel lattices

Yasin, Z. *Annals of Nuclear Energy*, 2009, 36, (10), 1635–1638.

A comparative study of fuel burn-up and radioactive inventory for the proliferation and proliferation resistant fuel lattices is carried out using the computer code WIMSD4. It is shown that by replacing the natural uranium metallic fuel and light water as coolant, such as used in the NRX/CIR, with the natural uranium oxide fuel and heavy water coolant, respectively, the core becomes proliferation resistant and environmental friendly as it produces about half the amount of ^{239}Pu and presents about half the amount of activities associated with major actinidies as compared to the original NRX/CIR core. The infinite multiplication factors and the ^{239}Pu produced in both fuel lattices are also compared.

10/02656 Corrosion of high burn-up structured UO_2 fuel in presence of dissolved H_2

Fors, P. *et al. Journal of Nuclear Materials*, 2009, 394, (1), 1–8.

The influence of high burn-up structured material on UO_2 corrosion has been studied in an autoclave experiment. The experiment was conducted on spent fuel fragments with an average burn-up of 67 GWd/tHM. They were corroded in a simplified groundwater containing 33 mM dissolved H_2 for 502 days. All redox sensitive elements were reduced. The reduction continued until a steady-state concentration was reached in the leachate for U at 1.5×10^{-10} M and for Pu at 7×10^{-11} M. The instant release of Cs during the first 7 days was determined to 3.4% of the total inventory. However, the Cs release stopped after release of 3.5%. It was shown that the high burn-up structure did not enhance fuel corrosion.

10/02657 Direct containment heating integral effects tests in geometries of European nuclear power plants

Meyer, L. *et al. Nuclear Engineering and Design*, 2009, 239, (10), 2070–2084.

The DISCO test facility at Forschungszentrum Karlsruhe (FZK) has been used to perform experiments to investigate direct containment heating (DCH) effects during a severe accident in European nuclear power plants, comprising the EPR, the French 1300 MWe plant P'4, the VVER-1000 and the German Konvoi plant. A high-temperature iron–alumina melt is ejected by steam into scaled models of the respective reactor cavities and the containment vessel. Both heat transfer from dispersed melt and combustion of hydrogen lead to containment pressurization. The main experimental findings are presented and critical parameters are identified. The consequences of DCH are limited in reactors with no direct pathway between the cavity and the containment dome (closed pit). The situation is more severe for reactors which do have a direct pathway between the cavity and the containment (open pit). The experiments showed that substantial fractions of corium may be dispersed into the containment in such cases, if the pressure in the reactor coolant system is elevated at the time of RPV failure. Primary system pressures of 1 or 2 MPa are sufficient to lead to full scale DCH effects. Combustion of the hydrogen produced by oxidation as well as the hydrogen initially present appears to be the crucial phenomenon for containment pressurization.

10/02658 Microstructural analysis of MTR fuel plates damaged by a coolant flow blockage

Leenaers, A. *et al. Journal of Nuclear Materials*, 2009, 394, (1), 87–94.

In 1975, as a result of a blockage of the coolant inlet flow, two plates of a fuel element of the BR2 reactor of the Belgian Nuclear Research Centre (SCK·CEN) were partially melted. The fuel element consisted of Al-clad plates with 90% ^{235}U enriched UAl_x fuel dispersed in an Al matrix. The element had accumulated a burn up of 21% ^{235}U before it was removed from the reactor. Recently, the damaged fuel plates were sent to the hot laboratory for detailed PIE. Microstructural changes and associated temperature markers were used to identify several stages in the progression to fuel melting. It was found that the temperature in the centre of the fuel plate had increased above 900–950 °C before the reactor was scrammed. In view of the limited availability of such datasets, the results of this microstructural analysis provide valuable input in the analysis of accident scenarios for research reactors.

10/02659 Mixture loss coefficient of safety valves used in nuclear plants

Benbella, S. *Nuclear Engineering and Design*, 2009, 239, (10), 1779–1788.

Theoretical and experimental investigations on the loss coefficient of gas–liquid mixture across safety relief valves have been carried out. Experiments were performed for three different types of safety valves and under different flow conditions. Using the Darcy equation and based on the presented experimental results, a new empirical correlation has been developed to calculate the loss coefficient and hence pressure loss. By consideration of flow contraction, high viscous fluids, Reynolds number and safety valve geometry, the model includes therefore the relevant primary influencing parameters. The reproductive accuracy of the proposed model and the statistical comparison, based on about 2000 measured data in the literature, demonstrated that the proposed model is the best overall agreement with the data. The standard deviation of the data is less than 27%. The model fits the data well and is sufficiently accurate for engineering purposes. The reported results of the tested safety relief valve are very important to improve the practical and safety design of the nuclear plants.

10/02660 Modeling transient heat transfer in nuclear waste repositories

Yang, S.-Y. and Yeh, H.-D. *Journal of Hazardous Materials*, 2009, 169, (1–3), 108–112.

The heat of high-level nuclear waste may be generated and released from a canister at final disposal sites. The waste heat may affect the engineering properties of waste canisters, buffers, and backfill material in the emplacement tunnel and the host rock. This study addresses the problem of the heat generated from the waste canister and analyses the heat distribution between the buffer and the host rock, which is considered as a radial two-layer heat flux problem. A conceptual model is first constructed for the heat conduction in a nuclear waste repository and then mathematical equations are formulated for modelling heat flow distribution at repository sites. The Laplace transforms are employed to develop a solution for the temperature distributions in the buffer and the host rock in the Laplace domain, which is numerically inverted to the time-domain solution using the modified Crump method. The transient temperature distributions for both the single- and multi-borehole cases are simulated in the hypothetical geological repositories of nuclear waste. The results show that the temperature distributions in the thermal field are significantly affected by the decay heat of the waste canister, the thermal properties of the buffer and the host rock, the disposal spacing, and the thickness of the host rock at a nuclear waste repository.

10/02661 Numerical investigation of flow mixture enhancement and infrared radiation shield by lobed forced mixer

Shan, Y. and Zhang, J.-Z. *Applied Thermal Engineering*, 2009, 29, (17–18), 3687–3695.

For the exhaust system of turbo-fan engine, the numerical calculation is used to investigate the different mixer configurations. The method using forward–backward ray-tracing and narrow-band model to predict the radiation from engine exhaust has been developed. The scheme has been validated in accuracy for spectral radiation intensity predictions, and some useful results of practical importance have been obtained to establish its ability for infrared signature analysis of exhaust system. A series of computations on exhaust system model have been conducted to obtain the effects of mixer configuration on the aerodynamic performances and infrared radiation intensity. The results indicate that the lobed forced mixer can increase the mixing efficiency by 65%, decrease the thrust coefficient by 3% only, but the infrared radiation of plum can reduce about 40% relative to confluent mixer at zero degree aspect (normal to nozzle outlet), especially. That means the lobed forced mixer has the remarkable ability to shelter the infrared radiation from the inside enclosure of nozzle.

10/02662 Phase characteristics of a number of U–Pu–Am–Np–Zr metallic alloys for use as fast reactor fuels

Burkes, D. E. *et al. Journal of Nuclear Materials*, 2010, 396, (1), 49–56.

Metallic fuel alloys consisting of uranium, plutonium, and zirconium with minor additions of americium and neptunium are under evaluation for potential use to transmute long-lived transuranic actinide isotopes in fast reactors. A series of test designs for the Advanced Fuel Cycle Initiative (AFCI) have been irradiated in the Advanced Test Reactor, designated as the AFC-1 and AFC-2 designs. Metal fuel compositions in these designs have included varying amounts of U, Pu, Zr, and minor actinides (Am, Np). Investigations into the phase behaviour and relationships based on the alloy constituents have been conducted using X-ray diffraction and differential thermal analysis. Results of these investigations, along with proposed relationships between observed behaviour and alloy composition, are provided. In general, observed behaviours can be predicted by a ternary U–Pu–Zr phase diagram, with transition temperatures being most dependent on U content. Furthermore, the enthalpy associated with transitions is strongly dependent on the as-cast microstructural characteristics.

10/02663 Physics features comparison of TRU burners: fusion/fission hybrids, accelerator-driven systems and low conversion ratio critical fast reactors

Salvatores, M. *Annals of Nuclear Energy*, 2009, 36, (11–12), 1653–1662.

This paper compares different types of TRU burners, sub-critical (as accelerator-driven systems and fusion fission hybrids) but also critical, low conversion ratio, fast reactors. To make a significant comparison, it is specified for which objective and within which strategy these systems can be envisaged. Beside intrinsic cost parameters, the associated fuel cycle issues can prove to be crucial for their deployment.

10/02664 Study of the radiotoxicity of actinides recycling in boiling water reactors fuel

François, J. L. *et al. Nuclear Engineering and Design*, 2009, 239, (10), 1911–1915.

In this paper the production and destruction, as well as the radiotoxicity of plutonium and minor actinides (MA) obtained from the multi-recycling of boiling water reactors (BWR) fuel are analysed. A BWR MOX fuel assembly, with uranium (from enrichment tails), plutonium and minor actinides is designed and studied using the HELIOS code. The actinides mass and the radiotoxicity of the spent fuel are compared with those of the once-through or direct cycle. Other type of fuel assembly is also analysed: an assembly with enriched uranium and minor actinides; without plutonium. For this study, the fuel remains in the reactor for four cycles, where each cycle is 18 months length, with a discharge burnup of 48 MWd/kg. After this time, the fuel is placed in the spent fuel pool to be cooled during 5 years. Afterwards, the fuel is recycled for the next fuel cycle; 2 years are considered for recycle and fuel fabrication. Two recycles are taken into account in this study. Regarding radiotoxicity, results show that in the period from the spent fuel discharge until 1000 years, the highest reduction in the radiotoxicity related to the direct cycle is obtained with a fuel composed of MA and enriched uranium. However, in the period after few thousands of years, the lowest radiotoxicity is obtained using the fuel with plutonium and MA. The reduction in the radiotoxicity of the spent fuel after one or two recycling in a BWR is however very small for the studied MOX assemblies, reaching a maximum reduction factor of 2.

Economics, policy, supplies, forecasts

10/02665 A computational model for evaluating the effects of attention, memory, and mental models on situation assessment of nuclear power plant operators

Lee, H.-C. and Seong, P.-H. *Reliability Engineering & System Safety*, 2009, 94, (11), 1796–1805.

Operators in nuclear power plants have to acquire information from human system interfaces (HSIs) and the environment in order to create, update, and confirm their understanding of a plant state, as failures of situation assessment may cause wrong decisions for process control and finally errors of commission in nuclear power plants. A few computational models that can be used to predict and quantify the situation awareness of operators have been suggested. However, these models do not sufficiently consider human characteristics for nuclear power plant operators. In this paper, the authors propose a computational model for situation assessment of nuclear power plant operators using a Bayesian network. This model incorporates human factors significantly affecting operators' situation assessment, such as attention, working memory decay, and mental model. As this proposed model provides quantitative results of situation assessment and diagnostic performance, it is expected that this model can be used in the design and evaluation of human system interfaces as well as the prediction of situation awareness errors in the human reliability analysis.

10/02666 A panel study of nuclear energy consumption and economic growth

Apergis, N. and Payne, J. E. *Energy Economics*, 2010, 32, (3), 545–549.

This study examines the relationship between nuclear energy consumption and economic growth for 16 countries within a multivariate panel framework over the period 1980–2005. Pedroni's heterogeneous panel cointegration test reveals there is a long-run equilibrium relationship between real GDP, nuclear energy consumption, real gross fixed capital formation, and the labour force with the respective coefficients positive and statistically significant. The results of the panel vector error correction model finds bidirectional causality between nuclear energy consumption and economic growth in the short-run while unidirectional causality from nuclear energy consumption to economic growth in the long-run. Thus, the results provide support for the feedback hypothesis associated with the relationship between nuclear energy consumption and economic growth.

10/02667 Decision support for selecting exportable nuclear technology using the analytic hierarchy process: a Korean case

Lee, D. J. and Hwang, J. *Energy Policy*, 2010, 38, (1), 161–167.

The Korean government plans to increase strategically focused R&D investment in some promising nuclear technology areas to create export opportunities of technology in a global nuclear market. The purpose of this paper is to present a decision support process for selecting promising nuclear technology with the perspective of exportability by using the analytic hierarchy process (AHP) based on extensive data gathered from nuclear experts in Korea. In this study, the decision criteria for evaluating the export competitiveness of nuclear technologies were determined, and a hierarchical structure for the decision-making process was systematically developed. Subsequently relative weights of decision criteria were derived using AHP methodology and the export competitiveness of nuclear technology alternatives was quantified to prioritize them. The implications of the results are considered with a viewpoint toward national nuclear technology policy.

10/02668 Development of a risk-informed accident diagnosis and prognosis system to support severe accident management

Ahn, K. and Park, S.-Y. *Nuclear Engineering and Design*, 2009, 239, (10), 2119–2133.

RISARD, risk-informed severe accident risk diagnosis system, is a computerized tool developed to improve a severe accident management (SAM) for a nuclear power plant and to effectively support the MCR and the TSC in executing the relevant SAM activities. In order to provide a diagnostic capability to a state of the plant and a prognostic capability for an anticipated accident progression, the system examines (a) a symptom-based diagnosis of a plant damage state (PDS) sequence in a risk-informing way and (b) a PDS sequence-based prognosis of key plant parameter behaviour, through a prepared database containing plant-specific severe accident risk (SAR)-related information. For a given accident, the replicated use of these two processes makes it possible to obtain information about the functional states of the plant and containment safety systems expected at the time of a severe accident as well as future trend of the key plant parameters that are essentially required for taking the relevant SAM action, eventually leading to an answer about the best strategy for SAM. The foregoing concept for an accident diagnosis and prognosis can give the SAM practitioners more time to take action for mitigating the consequences of the potential accident scenarios since they are made in a simple, fast, and efficient way through a prepared SAR database and it is useful especially when the plant information available for SAM is incomplete and limited. The main purpose of this paper is to (a) introduce the concept of the RISARD system proposed to support SAM and its implementation through a prepared OPR1000 plant- and MAAP code-specific SAR database and (b) assess prediction capabilities of major events expected during the evolution of a severe accident through the system.

10/02669 Evaluation of operators' mental workload of human-system interface automation in the advanced nuclear power plants

Jou, Y.-T. *et al. Nuclear Engineering and Design*, 2009, 239, (11), 2537–2542.

It has been expected that the automation of certain tasks in a control room would help decrease operators' mental workload, enhance situation awareness, and improve the whole system performance. However, there have been too many automation-induced system failures that would warrant a fresh look on the influences of automation. Automation problems include the reduction in the operator's system awareness, an increase in monitoring workload, and the degradation in manual skills. This study evaluates operators' mental workload and system performance during a human-system interface (HSI) automation in an advanced nuclear power plant (NPP). The reactor shutdown task and alarm reset task simulations were conducted in this study to evaluate operators' mental workload and performance. The results of this study indicated that for ensuring safe operating in NPPs, the design of automation needs to be carefully implemented. Task characteristics and degrees of automation should be carefully evaluated while designing HSIs. The reactor shutdown tasks studied in this paper suggest that a high level of automation design for the long period and low workload would be sufficient. On the other hand, the degree of automation of alarm reset task does not show a significant difference to the operator's mental workload. In conclusion, the human-system interface automation in advanced NPPs is suggested to be more flexible and needs to be continually improved.

10/02670 Human factors, human reliability and risk assessment in license renewal of a nuclear power plant

Vaurio, J. K. *Reliability Engineering & System Safety*, 2009, 94, (11), 1818–1826.

This paper describes human factors and human reliability assessments carried out as a part of operating license renewal of a nuclear power plant. The structure and contents of human factors assessments, the source material and the role of probabilistic safety assessment are described. Similar evaluations are recommended as an integral part of periodic safety reviews of regulated industrial facilities. The qualitative part of the human factors review is structured according to an international guide. The assessments are here enhanced with operating experience evaluations, measured by quantitative statistical data obtained from inspections and assessments made by plant safety and quality assurance personnel, by regulatory authorities and by peer reviews. The quantitative assessment is based on the roles and contributions of human errors in the accident risk of the target plant. The assessment uses importance measures quantified in probabilistic risk assessment. The scope and the quality of the risk assessment and the scope and the quality of human reliability assessments are also taken into account. Furthermore, the assessment describes how risk assessment can be used to reduce errors and improve human factors. The results tend to be very plant-specific, and the errors have very different importances in different operating states and for different initiating event categories. The results are useful for planning preventive actions, i.e. for preventing errors by developing and prioritizing human factors improvement activities.

10/02671 Performance improvement of artificial neural networks designed for safety key parameters prediction in nuclear research reactors

Mazrou, H. *Nuclear Engineering and Design*, 2009, 239, (10), 1901–1910.

The present work explores, through a comprehensive sensitivity study, a new methodology to find a suitable artificial neural network architecture which improves its performances capabilities in predicting two significant parameters in safety assessment, i.e. the multiplication factor k_{eff} and the fuel powers peaks $P_{\max}$ of the benchmark 10 MW IAEA LEU core research reactor. The performances under consideration were the improvement of network predictions during the validation process and the speed up of computational time during the training phase. To reach this objective, the authors used the Neural Network MATLAB Toolbox to carry out a widespread sensitivity study. Consequently, the speed up of several popular algorithms has been assessed during the training process. The comprehensive neural system was subsequently trained on different transfer functions, number of hidden neurons, levels of error and size of generalization corpus. Thus, using a personal computer with data created from preceding work, the final results obtained for the treated benchmark were improved in both network generalization phase and much more in computational time during the training process in comparison to the results obtained previously.

10/02672 Radioactive waste management plan for the PBMR (Pty) Ltd fuel plant

Makgae, M. E. *Nuclear Engineering and Design*, 2009, 239, (10), 2196–2200.

The Pebble Bed Modular Reactor (Pty) Ltd Fuel Plant (PFP) radioactive waste management plan caters for waste from generation, processing through storage and possible disposal. Generally, the amount of waste that will be generated from the PFP is Low and Intermediate Level Waste. The waste management plan outlines all waste streams and the management options for each stream. It also discusses how the Plant has been designed to ensure radioactive waste minimization through recycling, recovery, reuse, treatment before considering disposal. Compliance to the proposed plan will ensure compliance with national legislative requirements and international good practice. The national and the overall waste management objective is to ensure that all PFP wastes are managed appropriately by utilizing processes that minimize, reduce, recover and recycle without exposing employees, the public and the environment to unacceptable impacts. Both International Atomic Energy Agency (IAEA) and Department of Minerals and Energy (DME) principles act as a guide in the development of the strategy in order to ensure international best practice, legal compliance and ensuring that the impact of waste on employees, environment and the public is as low as reasonably achievable. The radioactive waste classification system stipulated in the Radioactive Waste Management Policy and Strategy 2005 will play an important role in classifying radioactive waste and ensuring that effective management is implemented for all waste streams, for example gaseous, liquid or solid wastes.

10/02673 The status quo of China's nuclear power and the uranium gap solution

Yang, G. and Huang, W. *Energy Policy*, 2010, 38, (2), 966–975.

Mainland China has 11 nuclear power reactors in commercial operation; six are under construction, and several more are slated for development in the near future. Additional reactors are planned, including some of the world's most advanced, to give a fivefold increase in nuclear capacity up to 40 GWe by 2020, and then a further three to fourfold increase to 120–160 GWe by 2030. The natural uranium supply, however, does not correspond to the speed of nuclear power development because of low production and poor deposits. After examining the existing nuclear power *status quo* in China, this paper provides an experimental model and a calculation method for the natural uranium needed that is based on the nuclear capacity to be installed in 2014. The natural uranium gap is further discussed through an analysis of the uranium resource distribution, reserves, and production in China, together with approaches to fill the gap. To meet the imminent uranium peak that will be required for fuel demands, China should diversify natural uranium sources and develop advanced nuclear power systems to save fuel.

10/02674 Thermal–hydraulics system codes uncertainty assessment: a review of the methodologies

Pourgol-Mohammad, M. *Annals of Nuclear Energy*, 2009, 36, (11–12), 1774–1786.

By revising the ECCS licensing rules in 1989, the USNRC has allowed the use of 'best estimate' thermal–hydraulics computer codes (such as RELAP5, TRAC, and TRACE), with the requirement that uncertainty analysis accompany the results. Several methodologies have been developed for the quantification of the uncertainties of such codes. These methodologies are either input-driven or output-driven. They disagree in definition for the uncertainty range, qualification and quantification steps, types of uncertainty sources considered, methods of assignment of uncertainty distribution or range to various parameters, approach to propagation of uncertainty, and the way the dynamic characteristics of TH codes are handled. The IMTHUA methodology, developed by the author, is a hybrid approach where an input-driven 'white box' method is augmented with output correction based on experimental results relevant to code output. This paper offers a comparative assessment of uncertainty analysis methodologies for thermal–hydraulics transient calculations. The methods will be compared based on their approaches for treatment of input, propagation, and code models and correlations, as well as output. Comprehensiveness, approach to data treatment, and interpretation of results are among the criteria for comparison. Several examples are provided to clarify the differences.

06 ELECTRICAL POWER SUPPLY AND UTILIZATION

Scientific, technical

10/02675 Chaotic particle swarm optimization based robust load flow

Acharjee, P. and Goswami, S. K. *International Journal of Electrical Power & Energy Systems*, 2010, 32, (2), 141–146.

A reliable load flow algorithm based on chaotic particle swarm optimization (CPSO) technique has been developed. To obtain optimum solution efficiently and accurately, an innovative formula for adaptive inertia weight factor (AIWF) has been introduced. Novel formulae for constriction factors have been designed for the load flow problems which are also adaptive. In addition to that, chaotic local search (CLS) is used with PSO to get rid of the local optima. To the best of the authors' knowledge, it is the first report of applying CPSO to solve load flow problems. The efficiency and effectiveness of the proposed algorithm has been tested on different standard and ill-conditioned test systems. The proposed method shows its robustness under critical conditions when conventional load flow methods fail.

10/02676 Combined production of second-generation biofuels and electricity from sugarcane residues

Walter, A. and Ensinas, A. V. *Energy*, 2010, 35, (2), 874–879.

This paper describes a preliminary analysis of two technological routes (based on hydrolysis and on gasification + Fischer–Tropsch conversion process) of biofuels production from cellulosic materials. In this paper it was considered the integration of the two alternative routes to a conventional distillery of ethanol production based on fermentation of sugarcane juice. Sugarcane bagasse is the biomass considered as input in both second-generation routes. Results show that the integration of gasification + FT process to a conventional distillery is slightly more efficient (from an energetic point of view) and also offers the advantage of products diversification (ethanol from the conventional plant, plus diesel, gasoline and more surplus electricity regarding the hydrolysis route). Considering typical Brazilian conditions, at this stage it is not possible to foresee any significant advantage of any of the alternatives, but potentially the gasification route would have an advantage regarding avoided GHG emissions depending on the emission factor of the electric sector in which cogeneration units will be installed.

10/02677 Congestion management enhancing transient stability of power systems

Esmaili, M. *et al. Applied Energy*, 2010, 87, (3), 971–981.

In a competitive electricity market, where market parties try to maximize their profits, it is necessary to keep an acceptable level of power system security to retain the continuity of electricity services to customers at a reasonable cost. Congestion in a power system is turned up due to network limits. After relieving congestion, the network may be operated with a reduced transient stability margin because of increasing the contribution of risky participants. In this paper, a novel congestion management method based on a new transient stability criterion is introduced. Using the sensitivity of corrected transient stability margin with respect to generations and demands, the proposed method so alleviates the congestion that the network can more retain its transient security compared with earlier methods. The proposed transient stability index is constructed considering the likelihood of credible faults. Indeed, market parties participate by their security-effective bids rather than raw bids. Results of testing the proposed method along with the earlier ones on the New-England test system elaborate the efficiency of the proposed method from the viewpoint of providing a better transient stability margin with a lower security cost.

10/02678 Discrete PSO algorithm based optimization of transmission lines loading in TNEP problem

Shayeghi, H. *et al. Energy Conversion and Management*, 2010, 51, (1), 112–121.

Transmission network expansion planning (TNEP) is a basic part of power system planning that determines where, when and how many new transmission lines should be added to the network. Until now, various methods have been presented to solve the static transmission network expansion planning (STNEP) problem. But in all of these methods, lines adequacy rate has not been considered at the end of planning horizon, i.e. expanded network misses adequacy after some times and needs to be expanded again. In this paper, expansion planning has been implemented by merging lines loading parameter in the STNEP and inserting investment cost into the fitness function constraints using discrete particle swarm optimization (DPSO) algorithm. Expanded network will possess a maximum adequacy to provide load demand and also the transmission lines overloaded later. The proposed idea has been tested on the Garvers network and an actual transmission network of the Azerbaijan regional electric company, Iran, and the results are compared with the decimal codification genetic algorithm (DCGA) technique. The results evaluation shows that the network will possess maximum efficiency economically. Also, it is shown that precision and convergence speed of the proposed DPSO-based method for the solution of the STNEP problem is superior to DCGA approach.

10/02679 Economic dispatch using particle swarm optimization: a review

Mahor, A. *et al. Renewable and Sustainable Energy Reviews*, 2009, 13, (8), 2134–2141.

Electrical power industry restructuring has created highly vibrant and competitive market that altered many aspects of the power industry. In this changed scenario, scarcity of energy resources, increasing power generation cost, environment concern, ever growing demand for electrical energy necessitate optimal economic dispatch. Practical economic dispatch (ED) problems have nonlinear, non-convex type objective function with intense equality and inequality constraints. The conventional optimization methods are not able to solve such problems as due to local optimum solution convergence. Meta-heuristic optimization techniques especially particle swarm optimization (PSO) has gained an incredible recognition as the solution algorithm for such type of ED problems in last decade. The application of PSO in ED problem, which is considered as one of the most complex optimization problem has been summarized in present paper.

10/02680 Electricity generation using a carbon-dioxide thermosiphon

Atrens, A. D. *et al. Geothermics*, 2010, 39, (2), 161–169.

There is an opportunity to expand the baseload geothermal electricity generation capacity through the development of engineered geothermal systems (EGS). Carbon dioxide (CO_2) could be used as an alternative to water to extract heat from these systems considering its advantages of ease of flow through the geothermal reservoir, strong innate buoyancy that permits the use of a thermosiphon rather than a pumped system over a large range of fluid flow rates, and lower dissolution of materials that lead to fouling. However, the thermodynamics of EGS using CO_2 to extract heat from subsurface rock masses is not well understood. Here the authors show that the wellbore frictional pressure losses are the dominant factor in CO_2-based EGS. Wellbore friction is the major limiter on the amount of energy that can be extracted from the reservoir by CO_2, as measured by the exergy available at the surface. The result is that CO_2 is less effective at energy extraction than water under conditions similar to past EGS trials. Nevertheless, CO_2 can perform well in lower permeability reservoirs, or if the wellbore diameter is increased. The results demonstrate that CO_2-based EGS need to be designed with the use of CO_2 in mind. This work is a starting point for the analysis of the surface infrastructure and plant design and economics of CO_2-based EGS.

10/02681 International light water nuclear fuel fabrication supply: are fabrication services assured?

Rothwell, G. *et al. Energy Economics*, 2010, 32, (3), 538–544.

This paper examines the cost structure of fabricating light water reactor (LWR) fuel with low-enriched uranium (LEU, with less than 5% enrichment). The LWR–LEU fuel industry is decades old, and (except for the high entry cost of designing and licensing a fuel fabrication facility and its fuel), labour and additional fabrication lines can be added at Nth-of-a-Kind cost to the maximum capacity allowed by a site license. The industry appears to be competitive: nuclear fuel fabrication capacity is assured with many competitors and reasonable prices. However, nuclear fuel assurance has become an important issue for nations now to considering new nuclear power plants. To provide this assurance many proposals equate 'nuclear fuel banks' (which would require fuel for specific reactors) with 'LEU banks' (where LEU could be blended into nuclear fuel with the proper enrichment) with local fuel fabrication. The policy issues (which are presented, but not answered in this paper) become (1) whether the construction of new nuclear fuel fabrication facilities in new nuclear power nations could lead to the proliferation of nuclear weapons, and (2) whether nuclear fuel quality can be guaranteed under current industry arrangements, given that fuel failure at one reactor can lead to forced shutdowns at many others.

10/02682 Interpretation of field observations of wind- and rain-wind-induced stay cable vibrations

Zuo, D. and Jones, N. P. *Journal of Wind Engineering and Industrial Aerodynamics*, 2010, 98, (2), 73–87.

Wind- and rain-wind-induced vibrations have been a long-standing and frequent problem for the stays of cable-stayed bridges. This paper summarizes characteristics of wind- and rain-wind-induced vibrations observed during two long-term full-scale measurement efforts. Based on these characteristics, and their relationship to the ambient meteorological environment (wind and rainfall), several distinct types of vibration are identified. The potential connection between the prevalent, large-amplitude, rain-wind-induced vibration and a type of large-amplitude dry cable vibration is explored. The characteristics of these large-amplitude vibrations are also compared to those of the classical Kármán-vortex-induced vibration, which provides considerable insight into the mechanisms of wind- and rain-wind-induced stay cable vibrations.

10/02683 Micro-grids project, part 1: analysis of rural electrification with high content of renewable energy sources in Senegal

Camblong, H. *et al. Renewable Energy*, 2009, 34, (10), 2141–2150.

Africa is the poorest continent in the world and this poverty is linked to the lack of access to energy of its population. A big part of inhabitants live in rural zones where the lack of energy and in particular of electricity is still more flagrant. The aim of the Micro-grids project was to promote the electrification of rural regions of Senegal by the installation of micro-grids with high content of renewable energies. This paper presents some results of this project. Surveys have been carried out in three regions of Senegal to study the needs of electrical energy of non-electrified rural villages' households. These surveys have led to the estimation of electricity needs of the concerned households. The potential in renewable energies of the three regions has also been examined. It has been concluded that the solar energy potential is excellent while the wind energy potential can be interesting in some specific sites. The biomass could also be an efficient source if livestock farming was properly managed in the future. Moreover, many events have been carried out in the three regions to analyse the obstacles for the development of micro-grids in the Senegalese energy context, and to establish suitable solutions to overcome these obstacles. The results presented in this paper have been used to design a rural electrification kit which is described in another paper. Now the Micro-grids' consortium hopes to set up a new project to apply the designed kit on some rural non-electrified villages.

10/02684 Microgrids project, part 2: design of an electrification kit with high content of renewable energy sources in Senegal

Alzola, J. A. *et al. Renewable Energy*, 2009, 34, (10), 2151–2159.

Senegal is one of the less developed countries in the world (position 158 in a list of 174 countries). 85% of its rural population does not have access to electricity and there's no doubt that this is an important barrier for socio-economic development. In this context, the project Microgrids aims at contributing to solve this problem. This project is part of the Intelligent Energy–Europe Programme supported by the European Commission. Its objective is the promotion and dissemination of the use of micro-grids with high content of renewable energy sources (RES) for the electrification of villages far away from the grid in Senegal. One of the results of the project was the analysis of rural electrification needs which is described elsewhere. This paper presents the design of an electrification kit based on the information provided by that analysis. After identifying necessary previous conditions for the sustainability of any electrification project, a methodology is proposed for the design of the electrification kit. This methodology is applied to a typical village and results are extended to differently sized villages in the areas of Thies, Fatick and Kaolack. Economic considerations are also included to establish the relationship between electrification costs and paying capability of the communities. Now the Microgrids' consortium hopes to set-up a new project to apply the designed kit on some rural non-electrified villages.

10/02685 Microhydro-PV-hybrid system: sizing a small hydro-PV-hybrid system for rural electrification in developing countries

Kenfack, J. *et al. Renewable Energy*, 2009, 34, (10), 2259–2263.

In most countries of equatorial Africa, it is difficult to satisfy power demand all year long by hydro sources alone. In some remote areas, where this is the case, a judicious combination of other renewable sources to form a hybrid system can help solve rural electrification problems. One of these combinations is the use of PV together with a diesel and batteries. The authors highlight the use of an optimization model to size such a system in a village in Cameroon.

10/02686 Multi-objective optimization of a trigeneration plant

Kavvadias, and Maroulis, Z. B. *Energy Policy*, 2010, 38, (2), 945–954.

A multi-objective optimization method was developed for the design of trigeneration plants. The optimization is carried out on technical, economical, energetic and environmental performance indicators in a multi-objective optimization framework. Both construction (equipment sizes) and discrete operational (pricing tariff schemes and operational strategy) variables were optimized based on realistic conditions. The problem is solved using a multi-objective evolutionary algorithm. An example of a trigeneration system in a 300 bed hospital was studied in detail in order to demonstrate the design procedure, the economic and energetic performance of the plant, as well as the effectiveness of the proposed approach even under fluctuating energy prices.

10/02687 Optimal utilization of renewable energy-based IPPs for industrial load management

Babu, C. A. and Ashok, S. *Renewable Energy*, 2009, 34, (11), 2455–2460.

Share of power generation from renewable energy sources has been steadily increasing all over the world, mainly due to the concern about clean environment. Cost of renewable power generation has reduced considerably during the last two decades due to technological advancements and at present some of the renewable energy sources can generate power at costs comparable with that of fossil fuels. In this paper, application of renewable energy-based power generation is proposed, for load management. The formulation utilizes non-linear programming technique for minimizing the electricity cost and reducing the peak demand, by supplementing power by renewable energy sources, satisfying the system constraints. A case study of 22 large-scale industries showed that, significant reduction in peak demand (about 34%) and electricity cost (about 14%) can be achieved, by the optimal utilization of the renewable energy from independent power producers (IPPs).

10/02688 Power generation from furfural using the microbial fuel cell

Luo, Y. *et al. Journal of Power Sources*, 2010, 195, (1), 190–194.

Furfural is a typical inhibitor in the ethanol fermentation process using lignocellulosic hydrolysates as raw materials. In the literature, no report has shown that furfural can be utilized as the fuel to produce electricity in the microbial fuel cell (MFC), a device that uses microbes to convert organic compounds to generate electricity. This study demonstrated that electricity was successfully generated using furfural as the sole fuel in both the ferricyanide-cathode MFC and the air-cathode MFC. In the ferricyanide-cathode MFC, the maximum power densities reached 45.4, 81.4, and $103\,\mathrm{W\,m^{-3}}$, respectively, when $1000\,\mathrm{mg\,L^{-1}}$ glucose, a mixture of $200\,\mathrm{mg\,L^{-1}}$ glucose and 5 mM furfural, and 6.68 mM furfural were used as the fuels in the anode solution. The corresponding Coulombic efficiencies (*CE*) were 4.0, 7.1, and 10.2% for the three treatments, respectively. For pure furfural as the fuel, the removal efficiency of furfural reached up to 95% within 12 h. In the air-cathode MFC using 6.68 mM furfural as the fuel, the maximum values of power density and *CE* were $361\,\mathrm{mW\,m^{-2}}$ ($18\,\mathrm{W\,m^{-3}}$) and 30.3%, respectively, and the COD removal was about 68% at the end of the experiment (about 30 h). Increase in furfural concentrations from 6.68 to 20 mM resulted in increase in the maximum power densities from 361 to $368\,\mathrm{mW\,m^{-2}}$, and decrease in *CE*s from 30.3 to 20.6%. These results indicated that some toxic and biorefractory organics such as furfural might still be suitable resources for electricity generation using the MFC technology.

10/02689 Real-time transient stabilization and voltage regulation of power generators with unknown mechanical power input

Kenné, G. *et al. Energy Conversion and Management*, 2010, 51, (1), 218–224.

A nonlinear adaptive excitation controller is proposed to enhance the transient stability and voltage regulation of synchronous generators with unknown power angle and mechanical power input. The proposed method is based on a standard third-order model of a synchronous generator which requires only information about the physical available measurements of relative angular speed, active electric power, infinite bus and generator terminal voltages. The operating conditions are computed online using the above physical available measurements, the terminal voltage reference value and the estimate of the mechanical power input. The proposed design is therefore capable of providing satisfactory voltage in the presence of unknown variations of the power system operating conditions. Using the concept of sliding mode equivalent control techniques, a robust decentralized adaptive controller which insures the exponential convergence of the outputs to the desired ones, is obtained. Real-time experimental results are reported, comparing the performance of the proposed adaptive nonlinear control scheme to one of the conventional AVR/PSS controller. The high simplicity of the overall adaptive control scheme and its robustness with respect to line impedance variation including critical unbalanced operating condition and temporary turbine fault, constitute the main positive features of the proposed approach.

10/02690 Study of the influence of heat exchangers' thermal resistances on a thermoelectric generation system

Astrain, A. *et al. Energy*, 2010, 35, (2), 602–610.

In this paper, a computational study of the influence of the heat exchangers' thermal resistances (in both the hot and cold side) on the efficiency of a thermoelectric generation device has been carried out. For this purpose, a computational model has been developed. This model uses the numerical method of finite differences to simulate the performance of the thermoelectric generation system, including the heat exchangers, the heat source and the heat sink. The accuracy of this computational model was experimentally verified, by constructing and testing a prototype. It was obtained that the maximum error between experimental and simulated values of electric power generated is lower than 5%. The generation of thermoelectric power, using as heat source the heat of the smoke from a paper mill's combustion boiler, has been studied too. The results demonstrated that it is possible to generate about 1 kW per metre of chimney height, that is, about 300 W/m^2. Therefore, it can be stated that this device has good prospects for the future.

10/02691 Suitable operational strategy for power interchange operation using multiple residential SOFC (solid oxide fuel cell) cogeneration systems

Wakui, T. *et al. Energy*, 2010, 35, (2), 740–750.

A suitable operational strategy for a power interchange operation using multiple residential solid oxide fuel cell (SOFC) cogeneration systems for saving energy is investigated by an optimization approach based on mixed-integer linear programming. In this power interchange operation, electricity generated by residential SOFC cogeneration systems is shared among households in a housing complex without allowing a reverse power flow to a commercial electric power system in order to increase electric load factors of the system. For an SOFC cogeneration system operated continuously with the minimum output, two types of operational strategies for the power interchange operation are adopted: an operation to meet the total demand for electricity in intended households by the electricity output of SOFC cogeneration systems and an operation to meet the demand for hot water in each household by the hot water output of the SOFC cogeneration system. To clarify a theoretical limit of the energy-saving effects of the two strategies, this study numerically analyses optimal operation patterns for 20 households on three representative days. The results show that the former operational strategy, which takes advantage of the high electricity generating efficiency of the SOFC, is more suitable for saving energy as compared to the latter strategy.

10/02692 Techno-economical analysis of off-grid hybrid systems at Kutubdia Island, Bangladesh

Nandi, S. K. and Ghosh, H. R. *Energy Policy*, 2010, 38, (2), 976–980.

Kutubdia is an island in the southern coast of Bangladesh where mainland grid electricity is not present or would not feasible in near future. Presently, electricity is generated using a diesel generator by Bangladesh Power Development Board (BPDB) for a limited time and location. Due to its remote location, the fuel cost in Kutubdia is very expensive. In the present study one-year recorded wind by Bangladesh Centre of Advanced Studies (BCAS) location and other three potential locations for hybrid system analysis is discussed. The system configuration of the hybrid is achieved based on a theoretical domestic load at the island. The sizing of the hybrid power systems is discussed with 0% and 5% annual capacity of shortage. This feasibility study indicates that wind–PV–diesel system is feasible with 0% capacity of shortage and wind–diesel system is feasible with 5% annual capacity of shortage at all locations. As 5% annual capacity of shortage can be considered, the wind–diesel hybrid system will reduce net present cost as well as cost of energy to about 20% and the diesel consumption on the island can be reduced to about 50% of its present annual consumption. Such a hybrid system will reduce about 44% greenhouse gases from the local atmosphere.

10/02693 UK scenario of islanded operation of active distribution networks with renewable distributed generators

Chowdhury, S. P. *et al. Renewable Energy*, 2009, 34, (12), 2585–2591.

This paper reports on the current UK scenario of islanded operation of active distribution networks with renewable distributed generators (RDGs). Different surveys indicate that the present scenario does not economically justify islanding operation of active distribution networks with RDGs. Anti-islanding protection schemes currently enforce the renewable distributed generators (RDGs) to disconnect immediately and stop generation for grid faults through loss of grid (LOG) protection system. This greatly reduces the benefits of RDG deployment. With rising RDG penetration, much benefit would be lost if the RDGs are not allowed to island only due to conventional operational requirement of utilities. For preventing disconnection of RDGs during LOG, several islanding operation, control and protection schemes are being developed. Technical studies clearly indicate the need to review parts of the ESQCR (Electricity Safety, Quality and Continuity Regulations) for successful islanded operations. Commercial viability of islanding operation must be assessed in relation to enhancement of power quality, system reliability and supply of potential ancillary services through network support. Demonstration projects under Registered Power Zone and Technical Architecture Projects should be initiated to investigate the usefulness of DG islanding. However these efforts should be compounded with a realistic judgement of the associated technical and economic issues for the development of future power networks.

10/02694 Variable structure control for power systems stabilization

Fernández-Vargas, J. and Ledwich, G. *International Journal of Electrical Power & Energy Systems*, 2010, 32, (2), 101–107.

The application of variable structure control (VSC) for power systems stabilization is studied in this paper. It is the application, aspects and constraints of VSC which are of particular interest. A variable structure control methodology has been proposed for power systems stabilization. The method is implemented using thyristor controlled series compensators. A three machine power system is stabilized using a switching line control for large disturbances which becomes a sliding control as the disturbance becomes smaller. The results demonstrate the effectiveness of the methodology proposed as an useful tool to suppress the oscillations in power systems.

Economics, policy, supplies, forecasts

10/02695 Asset life and pricing the use of electricity transmission infrastructure in Chile

Raineri, R. *Energy Policy*, 2010, 38, (1), 30–41.

Beyond the different approaches to set regulated prices for the use of infrastructure, a key parameter to determine regulated tariffs is the concept of asset life and how it changes with changes in the economic and regulatory context, which determines the optimal infrastructure investment and replacement policies. This study looks at the effects that changes in demand, the presence of substitutes and complements, the regulatory framework (both a pro or an anticompetitive framework), scale economies, and the investment planning horizon, have on the economic service life of an asset and the tariffs for its use. The authors find that as the electric industry becomes more competitive, a negative effect on the economic service life of electric electricity transmission should be expected. Also, numerical experiments illustrate an inverse relation between scale economies on investment and the economic service life of electricity transmission infrastructure. Further, the author looks at the biases on optimal investment that happen when optimal plans do not observe the life cycle of the investments and the economic service life of the equipment, as well as the inconsistency and biases on optimal investment and replacement policies that might result when the social planner optimal investment plan lacks of a long-term commitment.

10/02696 A method for generation of typical meteorological year

Ebrahimpour, A. and Maerefat, M. *Energy Conversion and Management*, 2010, 51, (3), 410–417.

The correct selecting of typical meteorological year is an important factor for accurate building energy simulation. In this study, the Sandia method has been applied to analyse the measured weather data of a 14-year period (1992–2005) in Bandarabass and to select the proper data for the typical meteorological year. Also, typical meteorological year has been generated by using Meteonorm and Weathergenrator software. Then the results of Sandia method and the two software programs have been compared with long-term average measured data for main parameters in the weather data file. Finally, those results which have the minimum difference in every month with the long-term average measured data and have best met Hall's persistence criterion have been used to select the typical meteorological year. It is found that, the results of Sandia method and Meteonorm software have good agreement with the long-term average measured data during the year and have best met Hall's persistence criterion.

10/02697 A MILP model for integrated plan and evaluation of distributed energy systems

Ren, H. and Gao, W. *Applied Energy*, 2010, 87, (3), 1001–1014.

In the last decade, technological innovations and a changing economic and regulatory environment have resulted in a renewed interest for distributed energy resources (DER). However, because of the lack of a suitable design tool, the expected potential of DER penetration is not always exerted sufficiently. In this paper, a mixed-integer linear programming model has been developed for the integrated plan and evaluation of DER systems. Given the site's energy loads, local climate data, utility tariff structure, and information (both technical and financial) on candidate DER technologies, the model minimizes overall energy cost for a test year by selecting the units to install and determining their operating schedules. Furthermore, the economic, energetic and environmental effects of the DER system can be evaluated. As an illustrative example, an investigation has been conducted of economically optimal DER system for an eco-campus in Kitakyushu, Japan. The result illustrates that gas engine is currently the most popular DER technology from the economic point of view. Although holding reasonable economic merits, unless combined with heat recovery units, the introduction of DER technologies may result in marginal or even adverse environmental effects. Furthermore, according to the results of sensitivity analysis, the optimal system combination and corresponding economic and environmental performances are more or less sensitive to the scale of energy demand, energy prices (both electricity and city gas), as well as carbon tax rate.

10/02698 A review on the economic dispatch and risk management considering wind power in the power market

Ren, B. and Jiang, C. *Renewable and Sustainable Energy Reviews*, 2009, 13, (8), 2169–2174.

With the rapid development of world economy, wind power has been given more and more consideration owing to its energy saving and environmental protection. But due to intermittency and unpredictability nature of wind power generation, many new problems come into being when infusing wind power into power network with conventional generators. Aiming at these difficulties, this paper presents a review on the historical research production of this theme. The models of economic dispatch schedule of wind power considering dissimilar actual condition, different optimized algorithms and risk management in the electric market are discussed and the future trend is prospected in this paper.

10/02699 A survey of the electricity consumption-growth literature

Payne, J. E. *Applied Energy*, 2010, 87, (3), 723–731.

This study discusses the various hypotheses associated with the causal relationship between electricity consumption and economic growth along with a survey of the empirical literature. The survey focuses on country coverage, variables selected and model specification, econometric approaches, various methodological issues, and empirical results. The results for the specific countries surveyed show that 31.15% supported the neutrality hypothesis; 27.87% the conservation hypothesis; 22.95% the growth hypothesis; and 18.03% the feedback hypothesis.

10/02700 Approach for standardization of off-grid electrification projects

Kumar, A. *et al. Renewable and Sustainable Energy Reviews*, 2009, 13, (8), 1946–1956.

Past experiences show that a large number of off-grid electrification projects fail because focus is generally given in technical installation without paying sufficient attention to the long-term sustainability of the projects. In such projects, several important steps, which need to be followed, are not covered. Moreover, there is no standardized approach, which could be followed while formulating the off-grid electrification projects. Therefore, there is a need for developing and benchmarking the systematic approaches, which could be followed for project planning and formulation. In this paper a modest attempt has been made to develop a decision making tool which involves approaches that are to be followed for entire planning and formulation of off-grid electrification project. The standardization of processes is expected to help in accelerating the implementation of off-grid electrification projects in an effective manner while fostering to achieve the national electrification targets in a stipulated timeframe.

10/02701 Can we accelerate the improvement of energy efficiency in aircraft systems?

Lee, J. J. *Energy Conversion and Management*, 2010, 51, (1), 189–196.

An aircraft is composed of systems that convert fuel energy to mechanical energy in order to perform work – the movement of people and cargo. Today, the fast-growing demand for air travel has outpaced the rate of improvement in the energy efficiency of aircraft systems. The increase in the total energy consumption and environmental impact of aviation necessitates a strategy to induce further technological and operational innovations to mitigate the increase in aircraft energy use and environmental effects. However, the uncertainty associated with the climate effects of jet engine emissions hinders further improvement to the energy efficiency of aircraft systems. Also the unique characteristics (e.g. trade-off between emissions species) of aircraft systems make it difficult to focus on abatement efforts. Based on a short review of how aircraft technology and operations relate to energy use and the future outlook for aircraft performance, energy use, and environmental impact, the key technology and policy issues related to improving the energy efficiency of aircraft systems are presented. Then, the drivers of technological change in aircraft systems are examined. Government regulation effects and industry characteristics as they relate to improvement of energy use are also presented. Based on these discussions, this paper provides insights on how to accelerate the induction of energy efficient, environmentally friendly innovations.

10/02702 CO_2 emission balances for different black liquor gasification biorefinery concepts for production of electricity or second-generation liquid biofuels

Pettersson, K. and Harvey, S. *Energy*, 2010, 35, (2), 1101–1106.

Black liquor gasification (BLG) is currently being developed as an alternative technology for energy and chemical recovery at chemical pulp mills. This study examines how different assumptions regarding systems surrounding the pulp mill affect the CO_2 emission balances for different BLG concepts. The syngas from the gasification process can be used for different applications; this study considers production of renewable motor fuels and electricity generation. Both a market pulp mill and an integrated pulp and paper mill are considered as host mill for the BLG plant. Furthermore, the consequences of limited availability of biomass are shown, i.e. increasing the use of biomass in a mill is not necessarily CO_2-neutral. The results show that the potential to reduce CO_2 emissions by introducing BLG is generally much higher for a market pulp mill than for an integrated pulp and paper mill. Electricity generation from the syngas is favoured when assuming high grid electricity CO_2 emissions where as motor fuel production is favoured when assuming low grid electricity CO_2 emissions. When considering the consequences of limited availability of biomass, the CO_2 emission balances are strongly affected, in some cases changing the results from a decrease to an increase of the CO_2 emissions.

10/02703 DSPSO–TSA for economic dispatch problem with nonsmooth and noncontinuous cost functions

Khamsawang, S. and Jiriwibhakorn, S. *Energy Conversion and Management*, 2010, 51, (2), 365–375.

This paper proposes a new approach based on particle swarm optimization (PSO) and tabu search algorithm (TSA). This proposed approach is called distributed Sobol PSO and TSA (DSPSO–TSA). In order to improve the convergence characteristic and solution quality of searching process, three mechanisms had been presented. Firstly, the Sobol sequence is applied to generate an inertia factor instead of the existing process. Secondly, a distributed process is used so as to reach the global solution rapidly. The search process is divided to multi-stages and used a short-term memory for recognition the best search history. Finally, to guarantee the global solution, TSA had been activated to adjust the obtained solution of DSPSO algorithm. To show its effectiveness, the proposed DSPSO–TSA is applied to test four case studies of economic dispatch (ED) problem considering non-smooth and non-continuous fuel cost functions of generating units. The simulation results obtained from DSPSO–TSA are compared with conventional approaches such as genetic algorithm (GA), TSA, PSO, and others in the literature. The comparison results show that the efficiency of proposed approach can reach higher quality solution and faster computational time than the conventional methods.

10/02704 Electric energy storage systems in a market-based economy: comparison of emerging and traditional technologies

Kazempour, S. J. *et al. Renewable Energy*, 2009, 34, (12), 2630–2639.
Unlike markets for storable commodities, electricity markets depend on the real-time balance of supply and demand. Although much of the present-day grid operate effectively without storage technologies, cost-effective ways of storing electrical energy can make the grid more efficient and reliable. This work addresses an economic comparison between emerging and traditional electric energy storage (EES) technologies in a competitive electricity market. In order to achieve this goal, an appropriate self-scheduling approach must first be developed for each of them to determine their maximum potential of expected profit among multi-markets such as energy and ancillary service markets. Then, these technologies are economically analysed using the internal rate of return index. Finally, the amounts of needed financial supports are determined for choosing the emerging technologies when an investor would like to invest on EES technologies. Among available EES technologies, natrium sulfur batteries and pumped-storage plants are considered as emerging and traditional technologies, respectively.

10/02705 Electricity consumption and economic growth in seven South American countries

Yoo, S.-H. and Kwak, S.-Y. *Energy Policy*, 2010, 38, (1), 181–188.
This paper attempts to investigate the causal relationship between electricity consumption and economic growth among seven South American countries, namely Argentina, Brazil, Chile, Columbia, Ecuador, Peru, and Venezuela using widely accepted time-series techniques for the period 1975–2006. The results indicate that the causal nexus between electricity consumption and economic growth varies across countries. There is a unidirectional, short-run causality from electricity consumption to real GDP for Argentina, Brazil, Chile, Columbia, and Ecuador. This means that an increase in electricity consumption directly affects economic growth in those countries. In Venezuela, there is a bidirectional causality between electricity consumption and economic growth. This implies that an increase in electricity consumption directly affects economic growth and that economic growth also stimulates further electricity consumption in that country. However, no causal relationships exist in Peru. The documented evidence from seven South American countries can provide useful information for each government with regard to energy and growth policy.

10/02706 Electricity consumption and economic growth: a cross-country analysis

Yoo, S.-H. and Lee, J.-S. *Energy Policy*, 2010, 38, (1), 622–625.
This paper attempts to ascertain whether there is a systematic relationship between electricity consumption and economic growth. To this end, a large set of data was used that covered 88 countries over the period, 1975–2004. A statistically significant inverted-U-shaped relationship between per-capita consumption of electricity and per-capita income is detected. Nevertheless, by using a purchasing power parity that is much higher than the per-capita income of all the countries in the world, the level of per-capita income is estimated at the peak point of per-capita electricity consumption to be $61,379 in 2000 constant international dollars. Moreover, the sample was segmented into Organization for Economic Cooperation and Development (OECD) countries and non-OECD countries, and the developed and developing countries analysed separately. The separate estimation shows that even though the peak income is higher than the average per-capita income, a statistically significant inverted-U-shaped relationship is found in OECD and developed countries but not in non-OECD and developing countries.

10/02707 Electricity consumption–growth nexus: the case of Malaysia

Chandran, V. G. R. *et al. Energy Policy*, 2010, 38, (1), 606–612.
This paper models the relationship between electricity consumption and real gross domestic product (GDP) for Malaysia in a bivariate and multivariate framework. Time series data was used for the period 1971–2003 and the bounds testing approach applied to search for a long-run relationship. The results revealed that electricity consumption, real GDP and price share a long-run relationship. The results of the autoregressive distributed lag (ARDL) estimates of long-run elasticity of electricity consumption on GDP were found to be around 0.7 and statistically significant. Finally, in the short-run, the results of the causality test showed that there is a unidirectional causal flow from electricity consumption to economic growth in Malaysia. From these findings it was concluded that Malaysia is an energy-dependent country.

10/02708 Electricity consumption-growth nexus: evidence from panel data for transition countries

Acaravci, A. and Ozturk, I. *Energy Economics*, 2010, 32, (3), 604–608.
This paper investigates the long-run relationship and causality issues between electricity consumption and economic growth in 15 Transition countries (Albania, Belarus, Bulgaria, Czech Republic, Estonia, Latvia, Lithuania, Macedonia, Moldova, Poland, Romania, Russian Federation, Serbia, Slovak Republic and Ukraine) by using the Pedroni panel cointegration method for the 1990–2006 period. Results suggest that the Pedroni panel cointegration tests do not confirm a long-term equilibrium relationship between electricity consumption per capita and real GDP per capita. Moreover, since no cointegration was found, error-correction mechanisms plus causality tests cannot be run for further steps in the long-term to investigate the causality between electricity consumption and economic growth. Overall, it can be said that the electricity consumption-related policies have no effect or relation on the level of real output in the long run for these countries. As a conclusion, the literature has conflicting results and there is no consensus either on the existence or the direction of causality between electricity consumption and economic growth. Thus, the findings of this study have important policy implications and it shows that this issue still deserves further attention in future research.

10/02709 Electricity demand and spot price forecasting using evolutionary computation combined with chaotic nonlinear dynamic model

Unsihuay-Vila, C. *et al. International Journal of Electrical Power & Energy Systems*, 2010, 32, (2), 108–116.
This paper proposes a new hybrid approach based on nonlinear chaotic dynamics and evolutionary strategy to forecast electricity loads and prices. The main idea is to develop a new training or identification stage in a nonlinear chaotic dynamic based predictor. In the training stage five optimal parameters for a chaotic based predictor are searched through an optimization model based on evolutionary strategy. The objective function of the optimization model is the mismatch minimization between the multi-step-ahead forecasting of predictor and observed data such as it is done in identification problems. The first contribution of this paper is that the proposed approach is capable of capturing the complex dynamic of demand and price time series considered resulting in a more accuracy forecasting. The second contribution is that the proposed approach run on-line manner, i.e. the optimal set of parameters and prediction is executed automatically which can be used to prediction in real-time, it is an advantage in comparison with other models, where the choice of their input parameters are carried out off-line, following qualitative/experience-based recipes. A case study of load and price forecasting is presented using data from New England, Alberta, and Spain. A comparison with other methods such as autoregressive integrated moving average (ARIMA) and artificial neural network (ANN) is shown. The results show that the proposed approach provides a more accurate and effective forecasting than ARIMA and ANN methods.

10/02710 Electricity procurement for large consumers based on Information Gap Decision Theory

Zare, K. *et al. Energy Policy*, 2010, 38, (1), 234–242.
In the competitive electricity market, consumers seek strategies to meet their electricity needs at minimum cost and risk. This paper provides a technique based on information gap decision theory (IGDT) to assess different procurement strategies for large consumers. Supply sources include bilateral contracts, a limited self-generating facility, and the pool. It is considered that the pool price is uncertain and its volatility around the estimated value is modelled using an IGDT model. The proposed method does not minimize the procurement cost but assesses the risk aversion or risk-taking nature of some procurement strategies with regard to the minimum cost. Using this method, the robustness of experiencing costs higher than the expected one is optimized and the related strategy is determined. The proposed method deals with optimizing the opportunities to take advantage of low procurement costs or low pool prices. A case study is used to illustrate the proposed technique.

10/02711 Energy management based on AM/FM/GIS for phase balancing application on distribution systems

Kuo, C.-C. and Chao, Y.-T. *Energy Conversion and Management*, 2010, 51, (3), 485–492.
Unbalanced feeder systems may deteriorate of power quality, and increase investment and operating costs for distribution systems. The phase swapping method recommends re-phasing circuits of laterals and transformers for making the current and voltage balanced and also reducing feeder loss and voltage drop. In this paper, an application program, based on the automated mapping/facilities management/geographic information system (AM/FM/GIS) is developed which contains a function of automatically computing Z-bus, load flow and phase balancing of feeders with phase swapping by using easily selecting of feeder on a graphic user interface application. Therefore, the relative data need not be keyed in manually. The presented phase balancing algorithm are based on database and related data structures developed on the AM/FM/GIS and Visual Basic software, which can be

integrated into the Tai-Power distribution automation system. Then, the phase balancing algorithm is designed to handle the load patterns and the load of transformers that connect specific feeders when evaluating phase swaps that will result in reduced daily circuit losses over all load points. The proposed application not only can effectively reduce the circuit loss and improves phase balancing, but also enhances power quality efficiently under easily using environment.

10/02712 Estimating the health damage costs of syrian electricity generation system using impact pathway approach

Hainoun, A. *et al. Energy*, 2010, 35, (2), 628–638.

Based on the simplified impact pathway approach the environmental impacts from airborne pollutant emissions of Syrian electricity generation system have been assessed and the associated external damage costs to human health have been evaluated. The obtained results indicate that the environmental impacts can add considerable external cost to the typical generation cost. The estimated externalities vary between 2.5 and 0.07 US-cents per generated kWh for heavy fuel oil and natural gas fired power plants respectively. For the fuel oil fired power plants the resulting external cost, arise mainly from Sulphates impact, amounts to about 25% of the present generation costs. These results indicate the advantage of natural gas fired power plants as clean generation technology and the necessity of supplying oil fired power plants with SO_2 emission reduction technologies.

10/02713 Forecast of electricity consumption in Cyprus up to the year 2030: the potential impact of climate change

Zachariadis, T. *Energy Policy*, 2010, 38, (2), 744–750.

This paper provides a forecast of electricity consumption in Cyprus up to the year 2030, based on econometric analysis of energy use as a function of macroeconomic variables, prices and weather conditions. If past trends continue electricity use is expected to triple in the coming 20–25 years, with the residential and commercial sectors increasing their already high shares in total consumption. Besides this reference scenario it was attempted to assess the impact of climate change on electricity use. According to official projections, the average temperature in the eastern Mediterranean is expected to rise by about 1 °C by the year 2030. Using the econometrically estimated model, the authors calculated that electricity consumption in Cyprus may be about 2.9% higher in 2030 than in the reference scenario. This might lead to a welfare loss of €15 million in 2020 and €45 million in 2030; for the entire period 2008–2030 the present value of costs may exceed €200 million (all expressed in constant 2007 euros). Moreover, the additional peak electricity load requirements in the future because of climate change were assessed as: extra load may amount to 65–75 MW in the year 2020 and 85–95 MW in 2030.

10/02714 Input-output table of electricity demand and its application

Mu, T. *et al. Energy*, 2010, 35, (1), 326–331.

It is very important for electric utility to determine dominant sectors which have more impacts on electricity consumption in national economy system. In this paper, an input-output perspective and methodology is proposed to handle this issue. The input-output table of electricity demand (IOTED) is put forward based on the input-output table of national economy (IOTNE). The relevancy of electricity demand in various sectors is revealed by means of electricity consumption chains, which are key components in the IOTED. Besides, a new concept, electricity demand multiplier, is presented to identify dominant sectors imposing great impacts on electricity demand quantitatively. In order to testify the effectiveness of the proposed methodology, a case based on provincial economy system in China is studied. Dominant sectors are identified and discussed.

10/02715 Mid-term hourly electricity forecasting based on a multi-rate approach

Pedregal, D. J. and Trapero, J. R. *Energy Conversion and Management*, 2010, 51, (1), 105–111.

Load demand prediction for mid or long-term horizons is important for the development of any model for electric power system planning. Literature on this topic is much scarcer than short-term forecasting, mainly due to the inherent difficulties in long-term modelling. The aim of this paper is to develop a general multi-rate methodology in order to forecast optimally load demand series sampled at an hourly rate for a mid-term horizon. This method may be considered as an extension of a previously published short-term approach to predict load and prices based on unobserved components. This approach implies the estimation of different models for the same data sampled at different rates (monthly and hourly in this paper). Each model incorporates the appropriate features of the data for its respective sampling interval, and both types of forecasts are integrated in one single forecast by efficient time aggregation techniques that result natural to implement in a State Space framework. The procedure is evaluated by a thorough forecasting experiment in which 365 rolling sets of one hour up to 12 weeks ahead of hourly forecasts are produced for the load demand registered at a transformer of a UK company. The results show that this method produces a notable reduction on the prediction error and its variability.

10/02716 Pay-as-bid based reactive power market

Amjady, N. *et al. Energy Conversion and Management*, 2010, 51, (2), 376–381.

In energy market clearing, the offers are stacked in increasing order and the offer that intersects demand curve, determines the market clearing price. In reactive power market, the location of reactive power compensator is so important. A low-cost reactive producer may not essentially be favourable if it is far from the consumer. Likewise, a high-cost local reactive compensator at a heavily loaded demand centre of network could be inevitably an alternative required to produce reactive power to maintain the integrity of power system. Given the background, this paper presents a day-ahead reactive power market based on pay-as-bid (PAB) mechanism. Generators expected payment function is used to construct a bidding framework. Then, total payment function of generators is used as the objective function of optimal power flow problem to clear the PAB-based market. The CIGRÉ-32 bus test system is used to examine the effectiveness of the proposed reactive power market.

10/02717 Promotion strategy of clean technologies in distributed generation expansion planning

Zangeneh, A. *et al. Renewable Energy*, 2009, 34, (12), 2765–2773.

Distributed generation expansion planning (DGEP) has been frequently reported in the literature around the world. In this scope, renewable technologies which are considered as a kind of distributed generations are developing due to their environmental benefits. However, only a few renewable energies have proven to be competitive so far, while their economic viability is also limited to certain regions of the world. In this paper, an encouraging mechanism is proposed in favour of clean technologies in the planning process. This mechanism is defined based on a grant function of emission not polluted which is paid to DG owners to promote renewable and clean technologies. In the planning process, a multi-objective optimization algorithm is applied to produce a Pareto set of optimal planning schemes by taking into account different objective functions (cost and grant functions). The best planning scheme among the Pareto set is chosen based on a composite utility which are obtained through a Monte Carlo simulation of uncertain situations. Distributed generation technologies which are considered in this paper are conventional and renewable technologies, namely photovoltaic, wind turbine, fuel cell, micro turbine, gas turbine, and reciprocal engine. To assess the ability of the proposed method, a typical distribution system is used for expansion planning under two environmental scenarios.

10/02718 Reliability and cost analyses of electricity collection systems of a marine current farm – a Taiwanese case study

Lee, M. Q. *et al. Renewable and Sustainable Energy Reviews*, 2009, 13, (8), 2012–2021.

The exploration of ocean energy for electric power production offers a sustainable option to enhance the use of renewable energy. In this article, the reliability and cost analyses results of electricity collection systems proposed for a marine current farm are presented. A methodology based on the probability density function of site current speed is developed to determine the speed specifications of marine current turbine. Reliability analyses are conducted by taking electricity collection structure, equipment failure rate and probability distribution of turbine power output into account. Non-delivered energy cost in conjunction with the investment cost, power loss, operations and maintenance costs are included in the cost analyses. Ocean current speed data measured at the Taiwan coastline situated in the Kuroshio stream path are used to calculate the life-cycle costs of the studied energy collection systems. Simulation results show that marine turbine parameters can be effectively specified, and a sectionalized radial collection structure provides an efficient scheme for harnessing ocean energy.

10/02719 Resiliency as a component importance measure in network reliability

Whitson, J. C. *et al. Reliability Engineering & System Safety*, 2009, 94, (10), 1685–1693.

This paper seeks to define the concept of resiliency as a component importance measure related to network reliability. Resiliency can be defined as a composite of: (1) the ability of a network to provide service despite external failures and (2) the time to restore service when in the presence of such failures. Although, resiliency has been extensively studied in different research areas, this paper will study the specific aspects of quantifiable network resiliency when the network is experiencing potential catastrophic failures from external events and/or influences, and when it is not known a priori which specific components within the network will fail. A formal definition for Category I resiliency is proposed and a step-by-step approach based on Monte-Carlo simulation to calculate it is defined. To illustrate the approach, two-terminal networks with varying degrees of redundancy, have been considered. The results obtained for test networks show that this new quantifiable concept of resiliency provides insight into the performance and topology of the network. Future use for this work could include methods for safeguarding critical network components and optimizing the use of redundancy as a technique to improve network resiliency.

10/02720 Targeting for cogeneration potential through total site integration

Bandyopadhyay, S. *et al. Applied Thermal Engineering*, 2010, 30, (1), 6–14.

Total site integration offers energy conservation opportunities across different individual processes and also to design as well as to optimize the central utility system. In total site integration of the overall process, indirect integration with intermediate fluids or through a central utility system are preferred as it offers greater advantages of flexibility and process control but with reduced energy conservation opportunities. To achieve the maximum possible indirect integration between processes assisted heat transfer, i.e. heat transfer outside the region between process pinch points, plays a significant role. A new concept is proposed in this paper for total site integration by generating a site level grand composite curve (SGCC). Proposed SGCC targets the maximum possible indirect integration as it incorporates assisted heat transfer. In this paper, a methodology is proposed to estimate the cogeneration potential at the total site level, utilizing the concept of multiple utility targeting on the SGCC. The proposed methodology to estimate the cogeneration potential is simple and linear as well as utilizes the rigorous energy balance at each steam header.

10/02721 The effect of contingency analysis on the nodal prices in the day-ahead market

Murphy, F. H. *et al. Energy Policy*, 2010, 38, (1), 141–150.

This study considers the effect of modelling branch-outage contingencies on locational marginal prices. To model contingencies in the day-ahead auction, a two-stage stochastic program was formulated. Rather than follow the current practice of including a list of possible contingencies that must be satisfied, the authors incorporated a larger set of contingencies in the model and allowed contingencies to result in load reductions/outages at a cost. The model can be used and interpreted in two ways. One is to look at the tradeoff between reliability and outage costs. Another is to consider the load losses resulting from a contingency to be consumer offers of load reductions in response to line outages as part of the day-ahead auction. In analysing the model structure, it was found that the prices in the model closer in definition to those currently used in the day-ahead auction did not maximize expected surplus because the day-ahead auction produced prices that assumed shortages will never occur. This raises issues with the design of auctions with important stochastic elements in the market. The results were presented for a 68-node grid with 86 branches (lines and transformers) to illustrate how prices and expected values change as the costs of outages are varied.

10/02722 The politics of power: electricity reform in India

Joseph, K. L. *Energy Policy*, 2010, 38, (1), 503–511.

Ongoing theft, corruption, and an artificially decreased pricing structure have made it nearly impossible for the state utilities in India to improve power service. As a result, industrial consumers across India exit the state-run system and rely on their own on-site power generation in order to ensure a consistent and reliable source of electricity. The 2003 Electricity Act encourages further power production from these captive plants through its open access clause. By encouraging the growth of these captive power plants, politicians in India set up a dual-track economy, whereby state-run and market-run production exist side-by-side. This strategy allows politicians to encourage private sector involvement in the electricity market, without jeopardizing the support of key political constituencies at the state level.

10/02723 Thermo-climatic cost of the domestic consumption products

Szargut, J. and Stanek, W. *Energy*, 2010, 35, (2), 1196–1199.

The thermo-climatic cost (TCC) expresses the cumulative emission of CO_2 burdening all the steps of production processes connected with the fabrication of particular consumption products. The TCC of the considered product results from the consumption of semi-finished products and energy carriers. The TCC of hydrocarbon fuels contains three components: the immediate emission of CO_2 resulting from the combustion of carbon, the TCC of delivery and processing and the TCC resulting from import of fuels. The TCC-component connected with import results from the TCC of the domestic products exported in order to gain the financial means for import. The values of the TCC can be used for the minimization of climatic damages by the selection of the production technology or the design and operation parameters of new processes.

10/02724 Use of multi-criteria decision analysis to explore alternative domestic energy and electricity policy scenarios in an Irish city-region

Browne, D. *et al. Energy*, 2010, 35, (2), 518–528.

In this paper, multi-criteria decision analysis (MCDA) was used to assess six policy measures or scenarios relating to residential heating energy and domestic electricity consumption, using an Irish city-region as case study. The analysis was undertaken using a modified version of MCDA based on the NAIADE (Novel Approach to Imprecise Assessment and Decision Environments) software and involved a decision output based on a mix of qualitative and quantitative assessment, which offered a ranking of options. It was concluded that Scenario 2, which proposes reducing energy and electricity consumption, was the most preferable option and Scenario 3, which proposes increasing the contribution of wood waste, was the least preferable option. This suggests that absolute reduction and demand management should be prioritized over fuel substitution or renewable energy technologies. MCDA was also compared with ecological footprint (EF) analysis for the same set of scenarios and it was found that both metrics show that Scenario 2 is preferable. However, MCDA shows that Scenario 3 is the least preferable scenario, whereas EF analysis suggests that Scenario 4 is, i.e. increased contribution of short rotation coppice. This suggests that a mix of assessment tools/indicators should be used when attempting to identify the most justifiable policy options as different indicators reflect different policy aspects.

10/02725 Valuating risk from sales contract offer maturity in electricity market

Bartelj, L. *et al. International Journal of Electrical Power & Energy Systems*, 2010, 32, (2), 147–155.

The electricity retail business has always been exposed to a significant risk due to a very volatile nature of the wholesale electricity market. Recently, this trend has been accelerating, as electricity-forward price can rise or fall during one day by an amount comparable to the retailer's margin. As a result, the risk that arises from sales contract offer maturity can significantly reduce or even neutralize the retailer's profit. To develop a mitigation strategy for this risk, a retailer clearly needs a model for a detailed risk analysis. Many attempts have been made to analyse several risk issues of an electricity retail company, but so far none has explored and evaluated the sales contract offer maturity risk. This paper presents a fundamental model for evaluating this risk and a methodology for its use, and compares its analytical performance with traditional techniques obtained from the option-pricing theory. A realistic example illustrates the use and the benefits of the proposed model in risk analysis of the electricity retail business.

10/02726 What trends in energy efficiencies? Evidence from a robust test

Pen, Y. L. and Sévi, B. *Energy Economics*, 2010, 32, (3), 702–708.

Modelling of the long-run behaviour of energy and oil intensities is crucial in many respects. This paper considers whether this long-run behaviour should be modelled as a deterministic or a stochastic trend or both. The authors first applied a test for a deterministic trend robust to uncertainty about the stochastic trend. The results indicated that, for the period 1960–2004, energy intensities of only eight OECD countries out of 25 included a negative deterministic trend, three included a positive one and 14 seemed to be better modelled by a stochastic trend only. When considering a sample of 73 non-OECD countries on the period 1971–2004, it was shown that only 22 exhibited a deterministic trend (negative for 15 countries and positive for seven countries). A similar analysis for oil intensity led to the rejection of the hypothesis of an insignificant deterministic trend for seven OECD countries out of 23 for the period 1965–2004 and 11 non-OECD countries out of 40 for the period 1971–2004. In the next step, standard unit root tests were applied and it was found that the unit root hypothesis is not very often rejected. It was concluded that a main feature of energy intensities is the presence of a stochastic trend.

10/02727 When do firms generate? Evidence on in-house electricity supply in Africa

Steinbuks, J. and Foster, V. *Energy Economics*, 2010, 32, (3), 505–514.

This paper attempts to identify the underlying causes and costs of own generation of electric power in Africa. Rigorous empirical analysis of 8483 currently operating firms in 25 African countries shows that the prevalence of own generation would remain high (at around 20%) even if power supplies were perfectly reliable, suggesting that other factors such as firms' size, emergency back-up and export regulations play a critical role in the decision to own a generator. The costs of own-generation are about three times as high as the price of purchasing (subsidized) electricity from the public grid. However, because these generators only operate a small fraction of the time, they do not greatly affect the overall average cost of power to industry. The benefits of generator ownership are also substantial. Firms with their own generators report a value of lost load of less than US$50 per hour, compared with more than US$150 per hour for those without. Nevertheless, when costs and benefits are considered side by side, the balance is not found to be significantly positive.

07 STEAM RAISING

Boiler operation/design

10/02728 A data-driven approach for steam load prediction in buildings

Kusiak, A. *et al. Applied Energy*, 2010, 87, (3), 925–933.

Predicting building energy load is important in energy management. This load is often the result of steam heating and cooling of buildings. In this paper, a data-driven approach for the development of a daily steam load model is presented. Data-mining algorithms are used to select significant parameters used to develop models. A neural network ensemble with five MLPs (multi-layer perceptrons) performed best among all data-mining algorithms tested and therefore was selected to develop a predictive model. To meet the constraints of the existing energy management applications, Monte Carlo simulation is used to investigate uncertainty propagation of the model built by using weather forecast data. Based on the formulated model and weather forecasting data, future steam consumption is estimated. The latter allows optimal decisions to be made while managing fuel purchasing, scheduling the steam boiler, and building energy consumption.

10/02729 Comparison of particle emissions from small heavy fuel oil and wood-fired boilers

Sippula, O. *et al. Atmospheric Environment*, 2009, 43, (32), 4855–4864.

Flue gas emissions of wood and heavy fuel oil (HFO) fired district heating units of size range 4–15 MW were studied. The emission measurements included analyses of particle mass, number and size distributions, particle chemical compositions and gaseous emissions. Thermodynamic equilibrium calculations were carried out to interpret the experimental findings. In wood combustion, PM1 (fine particle emission) was mainly formed of K, S and Cl, released from the fuel. In addition PM1 contained small amounts of organic material, CO_3, Na and different metals of which Zn was the most abundant. The fine particles from HFO combustion contained varying transient metals and Na that originate from the fuel, sulphuric acid, elemental carbon (soot) and organic material. The majority of particles were formed at high temperature (>800 °C) from V, Ni, Fe and Na. At the flue gas dew point (125 °C in undiluted flue gas) sulphuric acid condensed forming a liquid layer on the particles. This increases the PM1 substantially and may lead to partial dissolution of the metallic cores. Wood-fired grate boilers had 6–21-fold PM1 and 2–23-fold total suspended particle concentrations upstream of the particle filters when compared to those of HFO-fired boilers. However, the use of single field electrostatic precipitators (ESP) in wood-fired grate boilers decreased particle emissions to same level or even lower as in HFO combustion. On the other hand, particles released from the HFO boilers were clearly smaller and higher in number concentration than those of wood boilers with ESPs. In addition, in contrast to wood combustion, HFO boilers produce notable SO_2 emissions that contribute to secondary particle formation in the atmosphere. Due to vast differences in concentrations of gaseous and particle emissions and in the physical and chemical properties of the particles, HFO and wood fuel based energy production units are likely to have very different effects on health and climate.

10/02730 Evaluation of the effects of the operation strategy of a steam power plant on the residual life of its devices

Mirandola, A. *et al. Energy*, 2010, 35, (2), 1024–1032.

In the deregulated market scenario wider power generation flexibility with respect to the past is needed; on the other hand, frequent changes of the operating conditions may reduce the life of the most critical components, such as steam heaters or turbine blades. Fatigue failures produced by cyclic thermal and/or mechanical stresses will be considered in this work. The estimation is based on creep and fatigue failure models and is applied at the component level. In particular, in this paper evaluation of the impact of thermo-mechanical fatigue in the superheater pipes of an actual coal power plant will be carried out to estimate its residual life. Then, this evaluation at the device level will be translated into plant level assessment. Actually, the last aim of the work is developing an on-line real-time procedure suitable to determine how the present operation choices may influence the residual life of the components and of the whole plant and how to manage the plant under design and off-design conditions. These results are helpful in order to optimize the plant operation over time, assess components state, plan its production schedule, and forecast the expected performance degradation.

10/02731 Fitness for service evaluation of cracked divider plate bolt locking tabs for nuclear steam generators

Yang, S. and Manning, B. W. *Nuclear Engineering and Design*, 2009, 239, (11), 2242–2264.

This paper is to address the structural integrity issues related to continued service without repair or replacement for cracked locking tabs on divider plates of nuclear steam generators. Significantly high residual stress introduced by cold bending of locking tabs at installation was simulated by elastic-plastic finite element method and considered in the fitness for service evaluation. Significant work hardening resulted from the accumulation of large and inhomogeneous plastic deformation introduced by the in situ bending was quantified and considered. Failure and degradation mechanisms for crack stability and propagation were identified. Linear elastic fracture mechanics theory with crack tip plastic zone correction was adopted to establish critical crack sizes. Life of safe operation of the cracked locking tabs from inspected crack sizes to the critical crack sizes was then evaluated. Initial crack sizes at installation were also established through a highly contrived backward fitting evaluation procedure.

10/02732 Heat transfer efficient thermal energy storage for steam generation

Adinberg, R. *et al. Energy Conversion and Management*, 2010, 51, (1), 9–15.

A novel reflux heat transfer storage (RHTS) concept for producing high-temperature superheated steam in the temperature range 350–400 °C was developed and tested. The thermal storage medium is a metallic substance, zinc–tin alloy, which serves as the phase change material (PCM). A high-temperature heat transfer fluid (HTF) is added to the storage medium in order to enhance heat exchange within the storage system, which comprises PCM units and the associated heat exchangers serving for charging and discharging the storage. The applied heat transfer mechanism is based on the HTF reflux created by a combined evaporation–condensation process. It was shown that a PCM with a fraction of 70 wt.% Zn in the alloy (Zn70Sn30) is optimal to attain a storage temperature of 370 °C, provided the heat source such as solar-produced steam or solar-heated synthetic oil has a temperature of about 400 °C (typical for the parabolic troughs technology). This PCM melts gradually between temperatures 200 and 370 °C preserving the latent heat of fusion, mainly of the Zn-component, that later, at the stage of heat discharge, will be available for producing steam. The thermal storage concept was experimentally studied using a lab scale apparatus that enabled investigating of storage materials (the PCM–HTF system) simultaneously with carrying out thermal performance measurements and observing heat transfer effects occurring in the system. The tests produced satisfactory results in terms of thermal stability and compatibility of the utilized storage materials, alloy Zn70Sn30 and the eutectic mixture of biphenyl and diphenyl oxide, up to a working temperature of 400 °C. Optional schemes for integrating the developed thermal storage into a solar thermal electric plant are discussed and evaluated considering a pilot scale solar plant with thermal power output of 12 MW. The storage should enable uninterrupted operation of solar thermal electric systems during additional hours daily when normal solar radiation is not sufficient.

10/02733 Hybrid model of steam boiler

Rusinowski, H. and Stanek, W. *Energy*, 2010, 35, (2), 1107–1113.

In the case of big energy boilers energy efficiency is usually determined with the application of the indirect method. Flue gas losses and unburnt combustible losses have a significant influence on the boiler's efficiency. To estimate these losses the knowledge of the operating parameters influence on the flue gases temperature and the content of combustible particles in the solid combustion products is necessary. A hybrid model of a boiler developed with the application of both analytical modelling and artificial intelligence is described. The analytical part of the model includes the balance equations. The empirical models express the dependence of the flue gas temperature and the mass fraction of the unburnt combustibles in solid combustion products on the operating parameters of a boiler. The empirical models have been worked out by means of neural and regression modelling.

10/02734 The estimation of lifetime distribution of Alloy 800 steam generator tubing

Pandey, M. D. *et al. Nuclear Engineering and Design*, 2009, 239, (10), 1862–1869.

Alloy 800 has been used for steam generator (SG) tubing for more than 30 years, primarily in CANDU reactors worldwide and in reactors in Germany. Extensive laboratory testing and in-service experience suggest that the Alloy 800 tubing has excellent resistance to corrosion-related degradation under appropriate operating conditions. In planning refurbishment of nuclear plants stations, a key concern is the longevity of existing SGs up to the 60-year lifetime of the refurbished plant. The paper reviews an existing methodology based on the concept of the improvement factor, and refines its estimation based on data specific to CANDU operating conditions. The paper presents a more advanced Bayesian probabilistic approach to estimate the degradation free lifetime distribution of Alloy 800 tubing, which is used to quantify the probability of degradation during the service life and to evaluate the impact of potential occurrences of degradation on reliability of SG tubing.

10/02735 The influence of membrane CO_2 separation on the efficiency of a coal-fired power plant

Kotowicz, J. *et al. Energy*, 2010, 35, (2), 841–850.

In this paper, the influence of membrane separation of CO_2 from flue gases and the impacts of the whole CCS process (CO_2 separation and compression) on the performance of a coal-fired power plant are studied. First, the effects of the characteristics of the membrane (selectivity and permeability) and the parameters of the process (feed and permeate pressure) on two indices, CO_2 recovery rate and CO_2 purity are analysed. Next, a method for determining the minimum power loss and efficiency loss of the power plant as a function of these calculated indices is described. Then, the power requirements and efficiency loss (up to 15.4 percentage points) because of the CCS installation are calculated. A method for reducing these losses through the integration of the CCS installation with the power plant is also proposed. The main aims of the integration are heat exchange between media and a decrease in the CO_2 temperature before compression. Implementing this process can result in a significant reduction of the efficiency loss by 8 percentage points.

08 COMBUSTION

Burners, combustion systems

10/02736 A means to estimate thermal and kinetic parameters of coal dust layer from hot surface ignition tests

Park, H. *et al. Journal of Hazardous Materials*, 2009, 168, (1), 145–155.

A method to estimate thermal and kinetic parameters of Pittsburgh seam coal subject to thermal runaway is presented using the standard ASTM E 2021 hot surface ignition test apparatus. Parameters include thermal conductivity (k), activation energy (E), coupled term (QA) of heat of reaction (Q) and pre-exponential factor (A) which are required, but rarely known input values to determine the thermal runaway propensity of a dust material. Four different dust layer thicknesses: 6.4, 12.7, 19.1 and 25.4 mm, are tested, and among them, a single steady state dust layer temperature profile of 12.7 mm thick dust layer is used to estimate k, E and QA. k is calculated by equating heat flux from the hot surface layer and heat loss rate on the boundary assuming negligible heat generation in the coal dust layer at a low hot surface temperature. E and QA are calculated by optimizing a numerically estimated steady state dust layer temperature distribution to the experimentally obtained temperature profile of a 12.7 mm thick dust layer. Two unknowns, E and QA, are reduced to one from the correlation of E and QA obtained at criticality of thermal runaway. The estimated k is 0.1 W/m K matching the previously reported value. E ranges from 61.7 to 83.1 kJ/mol, and the corresponding QA ranges from 1.7×10^9 to 4.8×10^{11} J/kg s. The mean values of E (72.4 kJ/mol) and QA (2.8×10^{10} J/kg s) are used to predict the critical hot surface temperatures for other thicknesses, and good agreement is observed between measured and experimental values. Also, the estimated E and QA ranges match the corresponding ranges calculated from the multiple tests method and values reported in previous research.

10/02737 A new heat release rate (HRR) law for homogeneous charge compression ignition (HCCI) combustion mode

García, M. T. *et al. Applied Thermal Engineering*, 2009, 29, (17–18), 3654–3662.

Homogeneous charge compression ignition (HCCI) engines are drawing attracting attention as the next-generation's internal combustion engine, mainly because of its very low NO_x and soot emissions and also for improvement in engine efficiency. Much research has been carried out in order to go deeper in this combustion process using multizone models or CFD codes. These simulation tools, although they can give a detailed view of the combustion process, are very time consuming and the results depend a lot on the initial conditions. A previous step to be considered in the simulation of the HCCI process is a heat release law evaluated from results of the experiment and a zero-dimensional model. This paper focuses on the development of a new heat release rate (HRR) law that models the HCCI process when the combustion chamber is considered as a homogeneous volume. The parameters of this law have been adjusted through an optimization process that has allowed to fit the combustion chamber pressure. All the engine operative conditions from low to full load have been successfully simulated with this HRR law, with the maximum error in the estimation of combustion chamber pressure less than 2%.

10/02738 Ash effects during combustion of lignite/biomass blends in fluidized bed

Vamvuka, D. *et al. Renewable Energy*, 2009, 34, (12), 2662–2671.

Aiming at investigating the role of minerals in evaluating co-firing applications of low rank coals and biomass materials, agricultural residues characteristic of the Mediterranean countries, one lignite and their blends with biomass proportions up to 20% wt, were burned in a lab-scale fluidized bed facility. Fly ashes and bed material were characterized in terms of mineralogical, chemical and morphological analyses and the slagging/fouling and agglomeration propensities were determined. The results showed that combustion of each fuel alone could provoke medium or high deposition problems. Combustion of raw fuels produced fly ashes rich in Ca, Si and Fe minerals, as well as K and Na minerals in the case of biomass samples. However, blending of the fuels resulted in a reduction of Ca, Fe, K and Na, while an increase of Si and Al elements in the fly ashes as compared to lignite combustion, suggesting lower deposition and corrosion problems in boilers firing these mixtures. The use of bauxite as an additive enriched bottom ash in calcium compounds. Under the conditions of the combustion tests, no signs of ash deposition or bed agglomeration were noticed.

10/02739 Catalytic reforming of the aqueous phase derived from fast-pyrolysis of biomass

Li, H. *et al. Renewable Energy*, 2009, 34, (12), 2872–2877.

To improve the economics of biomass fast-pyrolysis, the aqueous phase derived from fast-pyrolysis was reformed with bio-oil to produce hydrogen by using Ni-base catalyst in this paper. The effects of reaction conditions such as steam-to-carbon ratio, temperature and reaction time on catalytic reforming were studied and the results indicated that the developed process was effective and feasible.

10/02740 Characterization of fly ash from a hazardous waste incinerator in Medellin, Colombia

Cobo, M. *et al. Journal of Hazardous Materials*, 2009, 168, (2–3), 1223–1232.

Bag filter (BF) fly ash from a hazardous waste incinerator located in Medellín, Colombia was characterized. Particle size distribution, chemical composition, metal loading, surface area, morphology, and chemical environment were assessed before and after fly ash extraction with toluene. Fly ash consists of low surface area platelets of SiO_2 smaller than 0.5 μm agglomerated in spheres between 20 and 100 μm. High concentration of sodium chloride, carbon, and heavy metals such as Cu, Fe, Pb, Hg, Cd, Co and Mn are deposited over the fly ash surface. The carbon is oxidized and forms different structures such as amorphous carbon black, nano balls and more crystalline fullerenes like nano onions. The high concentration of dioxins, furans and dioxin-like PCBs (superior to 185 ng WHO-TEQ/g) is favoured by oxidized carbon, chlorine and metals such as Cu and Fe on the shell of the particles. Before and after toluene extraction, fly ash samples presented similar morphology. However, after extraction their particle size increased while their surface area decreased by 35% and the carbon and metal contents decreased by 35% and 50%, respectively.

10/02741 Diagnostic techniques for the monitoring and control of practical flames

Ballester, J. and García-Armingol, T. *Progress in Energy and Combustion Science*, 2010, 36, (4), 375–411.

The development of diagnostic methods suitable for the monitoring of practical flames is an important objective, which is receiving a growing attention and significant research efforts. This is motivated by the need to achieve a more precise description of the process and, ultimately, implement efficient and reliable control and optimization methods as a key step towards the development of more efficient, flexible, reliable and clean combustion systems. Many and interesting attempts have been proposed, involving widely different approaches in terms of the instrumentation utilized and the concepts proposed to convert sensorial information into various meaningful parameters. This article intends to review the techniques proposed in the literature for the monitoring of flames, either applied to or conceived for the monitoring of practical combustion equipment. It has been divided into four sections, dealing respectively with optical sensors, imaging techniques, pressure transducers and probing methods. A detailed analysis of the works published reveals that probably the main challenge in this field is the definition of the most representative flame signals and of their subsequent processing to derive the meaningful information required to diagnose the state of a flame or to drive a controller in an effective and safe manner. This together with the wide range of diagnostic needs and restrictions imposed by the different combustion situations probably explains the notable heterogeneity observed among the works published. In spite of the great efforts devoted, the techniques proposed for the advanced monitoring of practical flames are still at a development stage. However, significant advances in this field are expected in a near future, fostered by the urgent demands from the combustion industry and facilitated by the continuous progress in sensor technology, signal processing techniques and, not the least, in the understanding of combustion processes.

10/02742 Differential thermal analysis, thermal gravimetric analysis, and solid phase micro-extraction gas chromatography analysis of water and fuel absorption in diesel soot

Ayrault, C. *et al. Journal of Aerosol Science*, 2010, 41, (2), 237–241.

An experimental investigation was conducted to analyse the absorption characteristics of deposited diesel soot by differential thermal analysis, thermal gravimetric analysis, and solid phase micro-extraction gas chromatography analysis. The results showed that dry diesel soot contained 2–3%wt of water and a maximum of 5%wt hydrocarbons. Water wetted soot contained up to 40%wt water, while diesel wetted soot contained up to 60%wt hydrocarbons. The hydrocarbons extracted from the soot were primarily hydrocarbons higher than $C_{12}H_{26}$ with little evidence of lighter hydrocarbons.

10/02743 Experiment study of the altitude effects on spontaneous ignition characteristics of wood

Wang, Y. *et al. Fuel*, 2010, 89, (5), 1029–1034.

This paper has studied the influence of ambient pressure and oxygen content on spontaneous ignition of wood by conducting contrastive experiments with wood slab exposed to high temperature radiation at two different altitudes. The measurement of mass loss, time to ignition, and surface temperature of wood are carried out. Results show that mass loss rate of wood at high altitudes (3650 m) is higher than the one at low altitudes (50 m), while ignition delay time of the sample at high altitude is shorter. The surface temperatures at the time of ignition in the two different places are both close to each other, which indicates that the pressure did not affects the ignition temperature. The theoretical analysis on the phenomenon of different ignition behaviour of wood in these two altitude environments has been presented.

10/02744 Experimental characterization of gaseous species emitted by the fast pyrolysis of biomass and polyethylene

Ouiminga, S. K. *et al. Journal of Analytical and Applied Pyrolysis*, 2009, 86, (2), 260–268.

This study aims to experimentally characterize the carbonaceous and nitrogenous species, from the flash pyrolysis of millet stalks and polyethylene plastic bags, using the device of the tubular kiln, coupled to two gas analysers: analyser Fourier transform infrared (FTIR) and an analyser infrared non-dispersive. Gaseous products analysed are: CH_4, C_2H_2, C_2H_4, C_3H_8, C_6H_6, CO, CO_2, NO_2, NO, N_2O, HCN and NH_3. Whatever the temperature of thermal degradation, the pyrolysis shows the following in terms of mass. For the millet stalks, the gaseous compounds are formed mainly CO and CO_2 to the carbonaceous species, HCN and NH_3, for the nitrogenous species analysed. As regards the polyethylene bags, hydrocarbons for carbonaceous species and HCN, NH_3 and NO_2 for the nitrogenous species, are most abundant. In addition, the results suppose that in the experimental conditions, the hydrocarbon which is involved primarily in the formation of CO is ethylene C_2H_4. At the end of this characterization, the rate of carbon and nitrogen found in the volatile gas was determined. With millet stalks, there was about 45% of volatile carbon and 15% of the nitrogen of fuel found in gaseous products. The results obtained with the plastic bags give 68% carbon and 15% nitrogen found in the nitrogenous species analysed.

10/02745 Mercury control technologies for coal combustion and gasification systems

Pavlish, J. H. *et al. Fuel*, 2010, 89, (4), 838–847.

Development and testing of mercury control technologies have largely focused on coal-fired combustion systems, with less emphasis on advanced power systems. Mercury control is influenced by coal properties and chemistry, plant configuration, pollution control devices, flue gas conditions, and plant operations, which differ between combustion and gasification systems. Sorbents such as treated activated carbons have shown promising results in low-temperature environments; however, elevated temperature and reducing environments of many advanced systems remain challenging, requiring research and development to obtain acceptable mercury control levels. Concurrent pollutant/multipollutant control strategies that include CO_2 control are critically needed for both conventional and advanced power systems.

10/02746 Presumed PDF modeling of reactive two-phase flow in a three dimensional jet-stabilized model combustor

Bazdidi-Tehrani, F. and Zeinivand, Z. *Energy Conversion and Management*, 2010, 51, (1), 225–234.

The objective of the present work is to investigate the modelling of a two-phase reactive flow concerning a diesel oil/air flame in order to predict the turbulent flow behaviour and temperature distribution in a three dimensional jet-stabilized model combustion chamber. A finite volume staggered grid approach is adopted to solve the governing equations. The second-order upwind scheme is applied for the space derivatives of the advection terms in all transport equations. An Eulerian–Lagrangian formulation is used for the two-phase (gas–droplet) flow. The presumed probability density function (PDF) is taken on to model the heat release and the realizable k–ε turbulence model is applied for the flow predictions. The thermal radiation model for the gas-phase is based on the discrete ordinates method, adopting its S_4 approximation. Comparisons of present numerical predictions with available experimental data and also with another numerical solution employing different combustion and turbulence models reveal that the realizable k–ε model predicts jet flow behaviour more accurately than the standard k–ε model. Also, the presumed PDF model predicts the temperature distribution better than the eddy dissipation model, especially in the near wall region. Negligence of thermal radiation mode results in a failure to predict the concentration of NO species.

10/02747 Reaction kinetics of the combined pyrolysis and steam-gasification of carbonaceous waste materials

Piatkowski, N. and Steinfeld, A. *Fuel*, 2010, 89, (5), 1133–1140.

Synthesis gas production by steam-gasification of carbonaceous waste materials with high volatile contents (e.g. sewage and industrial sludge, fluff and scrap-tyre powder) is kinetically examined. A multiple pseudo-component first-order reaction model is formulated to describe the rates of the combined pyrolysis and gasification processes. Arrhenius-type kinetic parameters are determined by dynamic thermogravimetric experimental runs conducted in the temperature range 473–1476 K.

10/02748 Strategies for 2nd generation biofuels in EU – co-firing to stimulate feedstock supply development and process integration to improve energy efficiency and economic competitiveness

Berndes, G. *et al. Biomass and Bioenergy*, 2010, 34, (2), 227–236.

The present biofuel policies in the European Union primarily stimulate first-generation biofuels that are produced based on conventional food crops. They may be a distraction from lignocellulose-based second-generation biofuels – and also from biomass use for heat and electricity – by keeping farmers' attention and significant investments focusing on first-generation biofuels and the cultivation of conventional food crops as feedstocks. This article presents two strategies that can contribute to the development of second-generation biofuels based on lignocellulosic feedstocks. The integration of gasification-based biofuel plants in district heating systems is one option for increasing the energy efficiency and improving the economic competitiveness of such biofuels. Another option, biomass co-firing with coal, generates high-efficiency biomass electricity and reduces CO_2 emissions by replacing coal. It also offers a near-term market for lignocellulosic biomass, which can stimulate development of supply systems for biomass also suitable as feedstock for second-generation biofuels. Regardless of the long-term priorities of biomass use for energy, the stimulation of lignocellulosic biomass production by development of near term and cost-effective markets is judged to be a no-regrets strategy for Europe. Strategies that induce a relevant development and exploit existing energy infrastructures in order to reduce risk and reach lower costs, are proposed an attractive complement the present and prospective biofuel policies.

10/02749 Study on nitrogen diluted propane–air premixed flames at elevated pressures and temperatures

Tang, C. *et al. Energy Conversion and Management*, 2010, 51, (2), 288–295.

Using a high pressure constant volume combustion vessel, the propagation and morphology of spark-ignited outwardly expanding nitrogen diluted propane–air flames were imaged and recorded by schlieren photography and high-speed digital camera. The unstretched laminar burning velocities and Markstein lengths were subsequently determined over wide range of initial temperatures, initial pressures and nitrogen dilution ratios. Two recently developed mechanisms were used to predict the reference laminar burning velocity. The results show that the measured unstretched laminar burning velocities agree well with those in the literature and the computationally predicted results. The flame images show that the diffusional–thermal instability is promoted as the mixture becomes richer, and the hydrodynamic instability is increased with the increase of the initial pressure and it is decreased with the increase of dilution ratio. The normalized laminar burning velocities show a linear correlation with respect to the dilution ratio, indicating that the effect of nitrogen dilution is more obvious at higher pressures.

10/02750 Sulfur evolution from coal combustion in O_2/CO_2 mixture

Duan, L. *et al. Journal of Analytical and Applied Pyrolysis*, 2009, 86, (2), 269–273.

O_2/CO_2 coal combustion technology is considered as one of the most promising technologies for CO_2 sequestration due to its economical advantages and technical feasibility. It is significant to study the sulfur transfer behaviour of coal in O_2/CO_2 atmosphere for organizing combustion properly and controlling SO_2 emission effectively. To clarify the effect of atmosphere on the sulfur transfer behaviour, thermogravimetry coupled with Fourier Transform Infrared (TG-FTIR) system was employed to study the formation behaviour of sulfur-containing gas species from Xuzhou bituminous coal pyrolysis in CO_2 atmosphere compared with that in N_2 atmosphere. Also the SO_2 formation behaviours during Xuzhou bituminous coal combustion in O_2/N_2 and O_2/CO_2 atmospheres were investigated. Results show that COS is preferentially formed during the coal pyrolysis process in CO_2 atmosphere rather than in N_2 atmosphere. When temperature is above 1000 K, sulfate in the CO_2 atmosphere begins to decompose due to the reduction effect of CO, which comes from the CO_2 gasification. During coal combustion process, replacing N_2 with CO_2 enhances the SO_2 releasing rate. SO_2 emission increases first and then decreases as O_2 fraction increases in the O_2/CO_2 mixture. XPS result of the ash after combustion indicates that higher O_2 concentration elevates the sulfur retention ability of the mineral matter in the coal.

10/02751 The calcium looping cycle for large-scale CO_2 capture

Blamey, J. *et al. Progress in Energy and Combustion Science*, 2010, 36, (2), 260–279.

The reversible reaction between CaO and CO_2 is an extremely promising method of removing CO_2 from the exhaust of a power station, generating a pure stream of CO_2 ready for geological sequestration. The technology has attracted a great deal of attention recently, owing to a number of its advantages: the relatively small efficiency penalty which it imposes upon a power station (estimated at 6–8 percentage points, including compression of the CO_2); its potential use in large-scale circulating fluidized beds (a mature technology, as opposed to the vastly upscaled solvent scrubbing towers which would be required for amine scrubbing); its excellent opportunity for integration with cement manufacture (potentially decarbonizing both industries) and its extremely cheap sorbent (crushed limestone). Unfortunately, sorbent (CaO) derived from natural limestone markedly decreases in its reactivity over a number of cycles of reaction with CO_2. Much current and promising research involves the investigation of a number of different methods to either reduce the rate of decay in reactivity, to boost the long-term reactivity of the sorbent or to reactivate the sorbent. Technologies investigated include thermal pretreatment or chemical doping of natural sorbents and the production of artificial sorbents. Attrition of the limestone can be a problem during repeated cycling in, e.g. a circulating fluidized bed, and some of the strategies to enhance the long-term capacity of the limestone to take up CO_2 can increase attrition. Strategies to counteract attrition, such as pelletization of highly reactive materials, have succeeded in reducing, though not eliminating, this problem. Each of these topics is reviewed in detail here, as are potential competing reactions with sulfurous compounds and the large-scale integration of the calcium looping cycle with both a power station and a cement works, including a number of assessments of the economics of the cycle. A number of pilot plants demonstrating the technology have been constructed around the world. No major problems have been encountered thus far, and so calcium looping technology is currently moving to the demonstration scale in a number of locations.

10/02752 The case of co-firing: the market level effects of subsidizing biomass co-combustion

Lintunen, J. and Kangas, H.-L. *Energy Economics*, 2010, 32, (3), 694–701.

Biomass combustion in co-firing power plants has been treated differently in renewable electricity promoting policy schemes. Some policy schemes subsidize biomass co-combustion while some do not. This study analyses the impacts of a policy choice on the fuel uses, investment decisions, CO_2 emissions, and on the values of renewable electricity promoting policy instruments. In particular, the impacts of feed-in tariff and a subsidy to renewable energy are considered, together with the CO_2 emissions price. The authors present an electricity and heat market model, where all the solid fossil fuel power plants are able to co-fire biomass and fossil fuel. In the numerical application, the model is used to analyse the differences caused by the policy instruments. The results show that subsidizing biomass combustion in a co-firing power plant decreases the investments in pure renewable technology. However, the use of solid fossil fuels is not increased significantly. Also, the CO_2 intensity levels of electricity production are nearly equal whether biomass co-combustion is subsidized or not.

Fire safety

10/02753 Development of a new quantification method for a fire PSA

Jung, W. S. *et al. Reliability Engineering & System Safety*, 2009, 94, (10), 1650–1657.

For an internal fire analysis, fire scenarios are developed carefully and quantified in a sequential and iterative way in a traditional fire probabilistic safety assessment (PSA). However, there has been no proven explicit method to avoid these iterative quantifications until now. This study presents the Jung's single top and run (JSTAR) method that facilitates a simultaneous single quantification of all fire scenarios. The JSTAR method could be employed at the fire PSA phases of a quantitative screening or detailed analysis. Using the JSTAR method, accurate fire risks of a fault tree that has many negates could be calculated by avoiding the frequent house event propagations of the fire scenario conditions. Furthermore, the proposed JSTAR method is a simple and explicit method to build a single-top external event PSA model for a risk-monitoring system. The JSTAR method could be implemented easily by developing a small automatic conversion tool. Depending on the maintenance policy of a fire PSA model, a single-top fire PSA model that is created by the conversion tool could be maintained permanently or it could be temporarily generated and discarded. The use of the JSTAR method is recommended for all external event PSAs such as an internal flooding risk analysis.

10/02754 Experimental and analytical investigation of intermittent flame effect on radiant emission for pool fires

Ferng, Y. M. and Lin, C. H. *Nuclear Engineering and Design*, 2009, 239, (10), 1965–1970.

Radiation plays an important role in the fire protection safety of equipments, especially for cable trays in switchgear rooms of a nuclear power plant. Therefore, many research works had been focused on the radiant heat emitted from a fire over the last decades. The radiant heat is essentially emitted from both the persistent and intermittent flames. However, no previous studies had investigated this heat contributed from the intermittent flame. Therefore, experimental and analytical works are proposed in this paper to investigate the effect of intermittent flame on the radiant heat. Based on the experimental measurements for a 30 cm pool fire, at least 36% of total radiant heat is emitted from the intermittent flame, demonstrating the significance of its contribution of the radiant heat. In addition, a new analytical radiant model is also proposed herein, which considers the intermittent flame effect, the flame oscillation characteristics and the smoke contribution. Compared with the experimental data for the pool fires with the diameters of 14–38 cm, the distributions of radiant heat fluxes predicted by the present analytical model show good agreement qualitatively and quantitatively. The relative errors between experiments and predictions are less than about 10%.

10/02755 FDS simulation of the fuel fireball from a hypothetical commercial airliner crash on a generic nuclear power plant

Luther, W. and Müller, W. C. *Nuclear Engineering and Design*, 2009, 239, (10), 2056–2069.

In the aftermath of 9/11 events it became clear that the impact of a fast flying commercial airliner hitting the nuclear power plant (NPP) could no longer be excluded as a potential external hazard threatening the NPP safety. One of the potential consequences of the impact is the occurrence of a fireball, large enough to engulf the entire NPP. The knowledge about fireballs from air crashes is rather poor since it is only based on footage shot by chance. From careful physical and chemical examinations using first principles, it can be concluded that the physics and chemistry of the kerosene fireball are similar to BLEVE fireballs in gas tank accidents which have been studied during the last decades. In order to obtain an adequate understanding of the potential hazards to a NPP engulfed by a fireball a detailed analysis of the fireball is necessary. It is only by a detailed analysis that the effect of the NPP structures on the evolution of the fireball can be derived. Though the safety-relevant parts of the NPP are strong concrete structures, according to IAEA regulations the hypothesized entry of combustion products into ventilation or air supply systems and the entry of fuel into buildings through normal openings have to be analysed in detail. This requires local transient values of the safety-relevant fireball parameters. With the NPP being a very large structure an adequately detailed simulation requires large computing grids and substantial computing power. With the release of Version 5 of the Fire Dynamic Simulator (FDS) from NIST in 2007 a simulation tool is now available which is capable to perform simulations of large fireballs on sufficiently large computing grids. These fireball simulations can be performed also by any other CFD code in which the relevant models have been implemented. The FDS fireball simulation capabilities were validated with the help of a well-documented fireball event, in which 5.9 to of propane were burnt during a BLEVE impact experiment conducted by the German BAM in 1999. To demonstrate the applicability of FDS to nuclear safety analysis a simulation of the impact of a 90 to fireball on a generic NPP was performed. The results are presented in this paper and show that FDS release Version 5 is an adequate tool to analysis the effect of a fireball on a NPP, even if the largest possible amount of kerosene involved in the crash is assumed. The work presented in this paper is based on codes, papers, footage and material that are freely available on the Internet. The paper does not use any information that is not freely available on the Internet.

10/02756 Fire risk assessment of gas turbine propulsion system for LNG carriers

Moon, K. *et al. Journal of Loss Prevention in the Process Industries*, 2009, 22, (6), 908–914.

New and more efficient propulsion systems are being considered for LNG carriers. One of the proposed alternatives is a combination of a gas turbine with a heat recovery steam generator. This arrangement constitutes a novel approach which needs to be analysed by a combination of engineering analysis and risk assessments to compensate for the lack of experience. Of specific concern is the high pressure fuel supply system. This paper describes the dispersion and fire analyses performed to better understand the risks involved in this arrangement and identify design improvements.

10/02757 Oscillating behaviour of fire-induced air flow through a ceiling vent

Chow, W. K. and Gao, Y. *Applied Thermal Engineering*, 2009, 29, (16), 3289–3298.

Oscillations of fire-induced air flow through a ceiling vent in a compartment were considered in this study. Air flow through the vent was found to be induced by buoyancy or by pressure. A wave function was introduced as a perturbation to a control volume concerned. Oscillation growth, amplification, response and frequency was then studied by solving these key equations under practical conditions. Useful semi-empirical formula on those parameters was derived for fire safety engineering design. Although there are only limited experimental studies on oscillatory behaviour of fire-induced air flow through a horizontal vent, the theories proposed in this paper agreed fairly well with those experiments. The work in this study can be used for further studies with the new full-scale burning facility, the PolyU/HEU Assembly Calorimeter developed in Harbin, Heilongjiang, China, jointly built by The Hong Kong Polytechnic University (PolyU) and Harbin Engineering University (HEU).

10/02758 Smoke control of a fire in a tunnel with vertical shaft

Yoon, S.-W. *et al. Journal of Loss Prevention in the Process Industries*, 2009, 22, (6), 954–957.

The aim of this research is to find the optimum smoke extraction rate through the ventilation shaft in case of a fire in a long road tunnel. Furthermore, it is also investigated whether the current emergency ventilation design practice using a vertical shaft can limit the smoke propagation from a fully loaded gasoline tank lorry fire. For this research, scaled model experiments were carried out using a 20-m long model tunnel with a vertical shaft. A CFD modelling tool was also extensively utilized to investigate the extremely dangerous situation in which a fully loaded gasoline tank lorry is burning inside a long road tunnel.

10/02759 Thermal degradation study of intumescent flame retardants by TG and FTIR: melamine phosphate and its mixture with pentaerythritol

Wang, Z. *et al. Journal of Analytical and Applied Pyrolysis*, 2009, 86, (1), 207–214.

Thermal degradation of intumescent flame retardants, such as melamine phosphate (MP) and the mixture of MP and pentaerythritol (PER) was studied by TG, FTIR gas analyser (G-FTIR), and FTIR spectrometry. The results indicate that the degradation behaviour of MP or PER itself is different from the one of them in the mixture. The volatile degradation products of MP contain mainly NH_3, and H_2O, as well as small amounts of melamine (MEL), whereas no MEL is found in the degradation of the mixture of MP and PER. Moreover, degradation products of PER are composed of a lot of volatile combustibles such as formaldehydes, alcohols, and C–H compounds except for H_2O. The mixture of MP and PER, however, produces much less volatile combustibles during its degradation leading to the production of more charring materials.

10/02760 Thermal stability, latent heat and flame retardant properties of the thermal energy storage phase change materials based on paraffin/high density polyethylene composites

Cai, Y. *et al. Renewable Energy*, 2009, 34, (10), 2117–2123.

In the present work, the thermal energy storage phase change materials (PCM) based on paraffin/high density polyethylene (HDPE) composites were prepared by using twin-screw extruder technique. The morphology and properties of the PCM composites based on the flame retardant system with expanded graphite (EG) and ammonium polyphosphate (APP) were characterized by scanning electron microscope (SEM), differential scanning calorimeter (DSC), thermogravimetric analyses (TGA) and cone calorimeter tests. It was observed from SEM images that paraffin dispersed well in the three-dimensional net structure formed by the HDPE. The SEM images also indicated that the EG and APP were well dispersed in the PCM composites. The DSC measurements indicated that the additives of flame retardant had little effect on the temperatures of phase change peaks and thermal energy storage property. The TGA results showed that the loadings of the EG and APP increased the temperature of the maximum weight loss and the charred residue of the PCM composites at 650 °C, contributing to the improved thermal stability properties. It was revealed from the cone calorimeter tests that the peak of heat release rate (PHRR) decreased significantly. To further investigate the synergistic effect between the EG and APP, it was observed from SEM images that the homogeneous and compact charred residue structure after combustion contributed to the enhanced thermal stability, improved flammability and increased self-extinguishing properties of the PCM composites.

09 PROCESS HEATING, POWER AND INCINERATION

Energy applications in industry

10/02761 A Bayesian approach to modeling and predicting pitting flaws in steam generator tubes

Yuan, X. X. *et al. Reliability Engineering & System Safety*, 2009, 94, (11), 1838–1847.

Steam generators in nuclear power plants have experienced varying degrees of under-deposit pitting corrosion. A probabilistic model to accurately predict pitting damage is necessary for effective life-cycle management of steam generators. This paper presents an advanced probabilistic model of pitting corrosion characterizing the inherent randomness of the pitting process and measurement uncertainties of the in-service inspection (ISI) data obtained from eddy current (EC) inspections. A Markov chain Monte Carlo simulation-based Bayesian method, enhanced by a data augmentation technique, is developed for estimating the model parameters. The proposed model is able to predict the actual pit number, the actual pit depth as well as the maximum pit depth, which is the main interest of the pitting corrosion model. The study also reveals the significance of inspection uncertainties in the modelling of pitting flaws using the ISI data: without considering the probability-of-detection issues and measurement errors, the leakage risk resulted from the pitting corrosion would be under-estimated, despite the fact that the actual pit depth would usually be over-estimated.

10/02762 Analytical procedure to obtain internal parameters from performance curves of commercial thermoelectric modules

Palacios, R. *et al. Applied Thermal Engineering*, 2009, 29, (17–18), 3501–3505.

Manufacturers of commercial thermoelectric modules provide datasheets of the modules including information and graphs about the performance attained at several working conditions. Details about internal parameters are not made available to customers, because in the broad majority of the cases they are not necessary. However, when developing non-standard applications or conducting research projects it is sometimes necessary to make the modules work in different conditions than those shown in the performance curves. This paper shows a methodology to extract thermoelectric internal parameters from the information provided by performance curves, hence allowing scientists to predict the performance of the module at any working condition. The method is based on the basic equations that link thermal and electrical dynamics in which some parameters must be estimated. As a result it is possible to predict the behaviour of the modules if they are operated in a non-standard way. One good example is to simulate how a module designed for cooling applications will behave if used as a Seebeck module for power generation. The proposed methodology has been successfully applied to a commercial Peltier module for which the behaviour as a thermoelectric generator was simulated and then tested experimentally, attaining very similar results.

10/02763 Estimating the contribution of industrial facilities to annual PM10 concentrations at industrially influenced sites

Gladtke, D. *et al. Atmospheric Environment*, 2009, 43, (30), 4655–4665.

If measures to reduce the industrial discharge of PM10 shall be planned with high accuracy, a first step must be to estimate the contribution of single industrial facilities to the overall PM10 burden as accurately as possible. In northern Duisburg as an example, an area where iron and steel producing industry is concentrated, PM10 was measured at four sampling sites very close to an industrial complex of blast furnaces, a sinter plant, oxygen steel works and a coke oven plant for 9 months in 2006. At two sites metals in PM10 were determined. The results, together with analytical data of urban background sites in the region and data of wind direction and wind speed were used for an estimation of the contribution of single plants to the PM10 burden. A careful analysis of the data showed, that the data of PM10, calcium, iron and zinc measured at two sites close to the industrial area and information about the urban background aerosol were sufficient to calculate the PM10 contribution of the main single plants. The data could be compared with those of modelling.

10/02764 Evaluating the efficiency of integrated systems in the process industry–case: steam cracker

Tuomaala, M. *et al. Applied Thermal Engineering*, 2010, 30, (1), 45–52.

A literature survey indicates that decisions about whether to reject or accept an investment are largely based on financial factors. The survey also indicates that a comparison of different efficiency improvement studies is difficult because their results are not readily commensurable. From the management perspective, more information on the physical aspects affecting efficiency is needed. From the engineering perspective, studies on integrated processes deal with a number of criteria that are often in conflict with each other, and for which information is difficult to produce. This paper discusses ways to analyse efficiency improvement studies in integrated industrial processes. The paper demonstrates how these analyses could be made more comprehensive. The paper presents a case study where test runs and simulations were carried out to improve process efficiency by adjusting process operating parameters. The case study was re-evaluated using a novel approach that has been developed to assess the efficiency of integrated systems. This includes considerations from three design perspectives: energy efficiency, material efficiency and operational efficiency, which, when analysed simultaneously, result in a more complete set of design and evaluation criteria.

10/02765 Heuristic method for reactive energy management in distribution feeders

Hamouda, A. *et al. Energy Conversion and Management*, 2010, 51, (3), 518–523.

This paper proposes an efficient method for solving shunt capacitors sizing problem in radial distribution feeders. For this typical multi-objective optimization problem, the optimal number, sizes and locations of fixed shunt capacitors are determined using a sensitivity-based heuristic solution. In this method, based on Markov chains, the number of variables to be optimized is reduced by using the node sensitivities to locate capacitors. Only a limited number of critical nodes satisfy the problem constraints and are considered for receiving standard shunt capacitors that maximize a net saving function. In order to overcome any over-compensation, the voltage admissible limits, imposed by many authors, are substituted by a new constraint on the branch reactive currents. To demonstrate the effectiveness and feasibility of the proposed approach, comparative studies were conducted on several test systems. The results obtained were promising compared to those given by previous published techniques.

10/02766 Humidification tower for humid air gas turbine cycles: experimental analysis

Traverso, A. *Energy*, 2010, 35, (2), 894–901.

In the humid air turbine cycle, the humidification of compressed air can be provided by a pressurized saturator (i.e. humidification tower or saturation tower), this solution being known to offer several attractive features. This work is focused on an experimental study of a pressurized humidification tower, with structured packing. After a description of the test rig employed to carry out the measuring campaign, the results relating to the thermodynamic process are presented and discussed. The experimental campaign was carried out over 162 working points, covering a relatively wide range of possible operating conditions. It is shown that the saturator behaviour, in terms of air outlet humidity and temperature, is primarily driven by, in decreasing order of relevance, the inlet water temperature, the inlet water over inlet dry air mass flow ratio and the inlet air temperature. The exit relative humidity is consistently over 100%, which may be explained partially by measurement accuracy and droplet entrainment, and partially by the non-ideal behaviour of air–steam mixtures close to saturation. Experimental results have been successfully correlated using a set of new non-dimensional groups: such a correlation is able to capture the air outlet temperature with a standard deviation $\sigma = 2.8$ K.

10/02767 Integrated production and utility system approach for optimizing industrial unit operations

Agha, M. H. *et al. Energy*, 2010, 35, (2), 611–627.

To meet utility demands some industrial units use onsite utility system. Traditionally, the management of such type of industrial units is carried out in three sequential steps: scheduling of the manufacturing unit by minimizing inventory, estimating the utility needs of manufacturing unit and finally operation planning of the utility system. This article demonstrates the value of an integrated approach which couples the scheduling of manufacturing unit with operational planning of the utility system. A discrete-time mixed integer linear programming (MILP) model is developed to compare traditional and integrated approaches. Results indicate that the integrated approach leads to significant reduction in energy costs and at the same time decreases the emissions of harmful gases.

10/02768 IR and UV gas absorption measurements during NO_x reduction on an industrial natural gas fired power plant

Stamate, E. *et al. Fuel*, 2010, 89, (5), 978–985.

NO_x reduction of flue gas by plasma-generated ozone was investigated in pilot test experiments on an industrial power plant running on natural gas. Reduction rates higher than 95% have been achieved for a molar ratio O_3:NO_x slightly below two. Fourier transform infrared and ultraviolet absorption spectroscopy were used for spatial measurements of stable molecules and radicals along the reduction reactor. Reactions of O_3 injected in the flue gas in the reduction reactor were also modelled. Experiments are in good agreement with numerical simulations. The operation costs for NO_x reduction were estimated based on field tests measurements.

10/02769 Limestone fragmentation and attrition during fluidized bed oxyfiring

Scala, F. and Salatino, P. *Fuel*, 2010, 89, (4), 827–832.

Attrition/fragmentation of limestone under simulated fluidized bed oxyfiring conditions was investigated by means of an experimental protocol that had been previously developed for characterization of attrition/fragmentation of sorbents in air-blown atmospheric fluidized bed combustors. The protocol was based on the use of different and mutually complementary techniques. The extent and pattern of attrition by surface wear in the dense phase of a fluidized bed were assessed in experiments carried out with a bench scale fluidized bed combustor under simulated oxyfiring conditions. Sorbent samples generated during simulated oxyfiring tests were further characterized from the standpoint of fragmentation upon high velocity impact by means of a purposely designed particle impactor. Results showed that under calcination-hindered conditions attrition and fragmentation patterns are much different from those occurring under air-blown atmospheric combustion conditions. Noteworthy, attrition/fragmentation enhanced particle sulfation by continuously regenerating the exposed particle surface.

10/02770 Methodology of industry scale analysis under the constraint of regional resource capacity using HSY algorithm

Mo, H. *et al. Resources, Conservation and Recycling*, 2009, 53, (11), 631–638.

This paper develops a methodology of proper scale analysis for regional industry development, which can be used in industry planning with the consideration of regional resource capacities. In the face of different data sources and even data scarcity, alternative methods based on linear programming and quadratic programming algorithms for calculating the resource intensity factors are designed. Based on the empirical study of industrialization, initial scenarios of industry development were set. Using HSY algorithm, sensitive industries that may cause exceeding regional resource capacity can be identified, and the risk of exceeding can be predicted and expressed in probability. Furthermore, a proper scale range can be designed for these sensitive industries according to resource capacity. Taking the case of Dalian city in China, this paper estimated the regional urban development plan, various resources capacities were studied, and land resources were estimated to be the most critical resource for the city. The land resource depletion intensities of different industries are calculated by quadratic programming algorithm. Under the constraint of 427.56 km^2 available industrial land resources, the electronic and power industries have the most significant impact on total land use, if the scale of power industry exceeds 1.27 billion USD, the probability of land resource capacity breakthrough will be 50%.

10/02771 Modeling of biomass gasification in fluidized bed

Gómez-Barea, A. and Leckner, B. *Progress in Energy and Combustion Science*, 2010, 36, (4), 444–509.

Modelling of biomass gasification in bubbling and circulating fluidized bed (FB) gasifiers is reviewed. Approaches applied for reactor modelling, from black-box models to computational fluid-dynamic models, are described. Special attention is paid to comprehensive fluidization models, where semi-empirical correlations are used to simplify the fluid-dynamics. The conversion of single fuel particles, char, and gas is examined in detail. The most relevant phenomena to be considered in modelling of FB biomass gasifiers are outlined, and the need for further investigation is identified. An updated survey of published mathematical reactor models for biomass and waste gasification in FB is presented. The overall conclusion is that most of the FB biomass gasification models fit reasonably well experiments selected for validation, despite the various formulations and input data. However, there are few measurements available for comparison with detailed model results. Also, validation of models with data from full-scale FB biomass gasification units remains to be done.

10/02772 Performance evaluation of low cost adsorbents in reduction of COD in sugar industrial effluent

Parande, A. K. *et al. Journal of Hazardous Materials*, 2009, 168, (2–3), 800–805.

Studies on reduction of chemical oxygen demand (COD) in effluent from sugar industry have been carried out by employing different absorbents optimizing various parameters, such as initial concentration of adsorbate, pH, adsorbent dosage and contact time. Experimental studies were carried out in batches using metakaolin, tamarind nut carbon and dates nut carbon as adsorbents by keeping initial adsorbent dosage at 1 g l^{-1}, agitation time over a range of 30–240 min, adsorbent dosage at 100–800 mg l^{-1} by varying the pH range from 4 to 10. Characterization of there adsorbents were done using techniques such as Fourier transforms infra red spectroscopy (FTIR), X-ray diffraction (XRD) and scanning electron microscope (SEM). The experimental adsorption data fitted well to Langmuir and Freundlich adsorption isotherms. The isotherms of the adsorbents indicate appreciable adsorption capacity. Higher COD removal was observed at neutral pH conditions. Studies reveal that maximum reduction efficiency of COD takes place using metakaolin as an absorbent at a dosage of 500 mg l^{-1} in a contact time of 180 min at pH 7 and it could be used as an efficient absorbent for treating sugar industrial effluent.

10/02773 Reducing water consumption of an industrial plant cooling unit using hybrid cooling tower

Rezaei, E. *et al. Energy Conversion and Management*, 2010, 51, (2), 311–319.

Water consumption is an important problem in dry zones and poor water supply areas. For these areas use of a combination of wet and dry cooling towers (hybrid cooling) has been suggested in order to reduce water consumption. In this work, wet and dry sections of a hybrid cooling tower for the estimation of water loss was modelled. A computer code was also written to simulate such hybrid cooling tower. To test the result of this simulation, a pilot hybrid tower containing a wet tower and 12 compact air cooled heat exchangers was designed and constructed. Pilot data were compared with simulation data and a correction factor was added to the simulation. Ensuring that the simulation represents the actual data, it was applied to a real industrial case and the effect of using a dry tower on water loss reduction of this plant cooling unit was investigated. Finally feasibility study was carried out to choose the best operating conditions for the hybrid cooling tower configuration proposed for this cooling unit.

10/02774 Risk assessment and early warning systems for industrial facilities in seismic zones

Salzano, E. *et al. Reliability Engineering & System Safety*, 2009, 94, (10), 1577–1584.

Industrial equipments and systems can suffer structural damage when hit by earthquakes, so that accidental scenarios as fire, explosion and dispersion of toxic substances can take place. As a result, overall damage to people, environment and properties increases. The present paper deals with seismic risk analysis of industrial facilities where atmospheric storage tanks (anchored or unanchored to ground), horizontal pressurized tanks, reactors and pumps are installed. Simplified procedures and methodologies based on historical database and literature data on natural-technological (Na-Tech) accidents for seismic risk assessment are discussed. Equipment-specific fragility curves have been thus derived depending on a single earthquake measure, peak ground acceleration. Fragility parameters have been then transformed to linear probit coefficients in order to obtain reliable threshold values for earthquake intensity measure, both for structural damage and loss of containment. These threshold values are of great interest when development of active and passive mitigation actions and systems, safety management, and the implementation of early warning system are concerned. The approach is general and can be implemented in any available code or procedure for risk assessment. Some results of seismic analysis of atmospheric storage tanks are also presented for validation.

10/02775 Risk-based decision making method for maintenance policy selection of thermal power plant equipment

Carazas, F. G. and Souza, G. F. M. *Energy*, 2010, 35, (2), 964–975.

This study presents a decision-making method for maintenance policy selection of power plant equipment. The method is based on risk analysis concepts. The method first step consists in identifying critical equipment both for power plant operational performance and availability based on risk concepts. The second step involves the proposal of a potential maintenance policy that could be applied to critical equipment in order to increase its availability. The costs associated with each potential maintenance policy must be estimated, including the maintenance costs and the cost of failure that measures the critical equipment failure consequences for the power plant operation. Once the failure probabilities and the costs of failures are estimated, a decision-making procedure is applied to select the best maintenance policy. The decision criterion is to minimize the equipment cost of failure, considering the costs and likelihood of occurrence of failure scenarios. The method is applied to the analysis of a lubrication oil system used in gas turbines journal bearings. The turbine has more than 150 MW nominal output, installed in an open cycle thermoelectric power plant. A design modification with the installation of a redundant oil pump is proposed for lubricating oil system availability improvement.

10/02776 Statistical key variable analysis and model-based control for the improvement of thermal efficiency of a multi-fuel boiler

Shieh, S.-S. *et al. Fuel*, 2010, 89, (5), 1141–1149.

Burning multi-fuel, including gases, liquid fuels and coal, whose flow rates and heating values vary all the time, a typical boiler in the steel and iron plant poses a challenge to achieving optimal operation. The present study proposes to develop an adaptive data-driven thermal efficiency estimator of multi-fuel boilers based on statistical identification of key variables. With the available on-line efficiency model, the model-based controller is hence readily applicable to improve the boiler efficiency. Real operation data taken from two industrial boilers are used to verify the effectiveness of the proposed method. The first half part of data serves to develop statistical models while the second half part serves to be simulated as virtual plants. The application of the proposed methods improved 1.94% of the thermal efficiency of a boiler burning multi-gas and 0.73% of a boiler burning coal and multi-gas in the virtual plant simulations.

10/02777 The use of conservation supply curves in energy policy and economic analysis: the case study of Thai cement industry

Hasanbeigi, A. *et al. Energy Policy*, 2010, 38, (1), 392–405.

The cement industry is one of the largest energy-consuming industries in Thailand with high carbon dioxide (CO_2) emissions. Using a bottom-up electricity conservation supply curve (CSC) model, the cost effective and the total technical electricity-efficiency potential for the Thai cement industry in 2008 is estimated to be about 265 and 1697 gigawatt-hours (GWh) which account for 8% and 51% of the total electricity used in the cement industry in 2005, respectively. The fuel CSC model shows the cost-effective fuel-efficiency potential to be 17,214 terajoules (TJ) and the total technical fuel-efficiency potential equal to 21,202 TJ, accounting for 16% and 19% of the total fuel used in cement industry in 2005, respectively. The economic analysis in this paper shows how the information from the CSCs can be used to calculate the present value of net cost savings over a period of time taking into account the energy price escalation rate. The results from the policy scenario analysis show that the most effective and efficient policy scenario is the introduction of an energy-related CO_2 tax for the cement industry under a voluntary agreement program. This scenario results in 16.9% primary energy-efficiency improvement over a 5-year implementation period.

10 SPACE HEATING AND COOLING/HEAT PUMPS

10/02778 A comparison of the performances of adsorption and resorption refrigeration systems powered by the low grade heat

Wang, L. W. *et al. Renewable Energy*, 2009, 34, (11), 2373–2379.

In order to study the refrigeration performances of the resorption refrigeration technology, the resorption working pair of $BaCl_2$–$MnCl_2$–NH_3, which has the similar working requirements for the heat source and cooling source, and also could satisfy the similar refrigeration requirements with the adsorption working pair of $CaCl_2$–NH_3, is studied by simulation and experiments. In the simulation the mass transfer resistance is not considered for the systems, and the refrigeration performances related with heat transfer performances are studied, results show that the resorption refrigeration system has a higher refrigeration power and COP (coefficient of the refrigeration performance) because the refrigeration effect is generated by the reaction heat compared to the latent heat of evaporation. After the simulation the experimental test unit is constructed, and the experimental data are analysed. Results show that the resorption rate is influenced by the critical mass transfer performance very much, and the refrigeration performance is lower than that of adsorption system. The resorption system also has the problem of the larger refrigeration power loss for the reason of the sensible heat requirement of low temperature adsorber. How to improve the mass transfer performance of resorption system and decrease the influence on the refrigeration power by the sensible heat requirement of low temperature adsorber will be the key research directions for the application of resorption refrigeration systems.

10/02779 A solar thermal cooling and heating system for a building: experimental and model based performance analysis and design

Qu, M. *et al. Solar Energy*, 2010, 84, (2), 166–182.

A solar thermal cooling and heating system at Carnegie Mellon University was studied through its design, installation, modelling, and evaluation to deal with the question of how solar energy might most effectively be used in supplying energy for the operation of a building. This solar cooling and heating system incorporates $52\,m^2$ of linear parabolic trough solar collectors; a 16 kW double effect, water–lithium bromide (LiBr) absorption chiller, and a heat recovery heat exchanger with their circulation pumps and control valves. It generates chilled and heated water, dependent on the season, for space cooling and heating. This system is the smallest high temperature solar cooling system in the world. Till now, only this system of the kind has been successfully operated for more than one year. Performance of the system has been tested and the measured data were used to verify system performance models developed in the TRaNsient SYstem Simulation program (TRNSYS). On the basis of the installed solar system, base case performance models were programmed; and then they were modified and extended to investigate measures for improving system performance. The measures included changes in the area and orientation of the solar collectors, the inclusion of thermal storage in the system, changes in the pipe diameter and length, and various system operational control strategies. It was found that this solar thermal system could potentially supply 39% of cooling and 20% of heating energy for this building space in Pittsburgh, PA, if it included a properly sized storage tank and short, low diameter connecting pipes. Guidelines for the design and operation of an efficient and effective solar cooling and heating system for a given building space have been provided.

10/02780 Analysis of the nucleation of nanofluids in the ice formation process

Zhang, X. J. *et al. Energy Conversion and Management*, 2010, 51, (1), 130–134.

This paper presents a study on the impact of the wettability between the nanofluids and the metallic surface on the ice nucleation. The nanofluids consist of a basic liquid and the additive nanoparticles. Pure water is used as the basic fluid, and the nanoparticles, such as α-Al_2O_3, α-Al_2O_3 and SiO_2, are used as the additives. Three stainless steel vessels, in which the cooling surface has the roughness of 0.149 μm, 0.433 μm, and 0.729 μm, respectively, were used to achieve different wettablities. Based on the relationship between the contact angle (σ) and the critical nucleation radius (r^*), the nucleation mechanism on the metallic surface has been improved. When the cooling surface of the vessel is hydrophilic, the change of the contact angle (σ) would impose a greater influence on the critical nucleation radius (r^*) compared with when the surface is hydrophobic, resulting in a great change of the temperature at rupture of supercooling (T_{RSC}). And through adding different nanoparticles into the pure water, the different effects on decreasing the supercooling degree (ΔT_{SC}) were observed, which strongly lies on the wettability and the crystal structure similarity between the ice and the additives.

10/02781 Automated modelling of complex refrigeration cycles through topological structure analysis

Belman-Flores, J. M. *et al. Applied Thermal Engineering*, 2009, 29, (17–18), 3529–3535.

The authors have developed a computational method for analysis of refrigeration cycles. The method is well suited for automated analysis of complex refrigeration systems. The refrigerator is specified through a description of flows representing thermodynamic states at system locations; components that modify the thermodynamic state of a flow; and controls that specify flow characteristics at selected points in the diagram. A system of equations is then established for the refrigerator, based on mass, energy and momentum balances for each of the system components. Controls specify the values of certain system variables, thereby reducing the number of unknowns. It is found that the system of equations for the refrigerator may contain a number of redundant or duplicate equations, and therefore further equations are necessary for a full characterization. The number of additional equations is related to the number of loops in the cycle, and this is calculated by a matrix-based topological method. The methodology is demonstrated through an analysis of a two-stage refrigeration cycle.

10/02782 Building energy research in Hong Kong: a review

Ma, Z. and Wang, S. *Renewable and Sustainable Energy Reviews*, 2009, 13, (8), 1870–1883.

Hong Kong is located in a typical subtropical region. The buildings in Hong Kong are subjected to high cooling demands for their air-conditioning systems throughout most of the year, and their contribution toward the total energy consumption is about 40%. Therefore, energy efficiency in buildings is essential to reduce the global energy use and improve the local environmental sustainability. This paper provides an overall review of the building energy research and efforts in Hong Kong over the last decade. Various aspects and energy saving measures, including energy policy, energy audit, design, control, diagnosis, building performance evaluation and renewable energy systems, studied or used to enhance the energy efficiency in buildings are reviewed. A brief introduction of the Hong Kong Building Energy Codes (BEC) and Hong Kong Building Environmental Assessment Method (HK-BEAM) are also provided to present the efforts of the local government and community on energy efficiency in buildings. This review aims at providing building researchers and practitioners a better understanding of building's energy saving opportunities and approaches in cities particularly in subtropical regions and taking further proper actions to promote buildings energy efficiency and conservation.

10/02783 Computation of surface radiation and natural convection in a heated horticultural greenhouse

Mezrhab, A. *et al. Applied Energy*, 2010, 87, (3), 894–900.

This study analyses the effects of the radiation exchange inside a horticultural greenhouse, under winter climatic conditions, according to the number of squared heating tubes used. These ones, hot and isothermal, are equidistant inside the greenhouse volume. The governing differential equations are discretized using a finite volume method and the coupling pressure–velocity problem is carried out by the SIMPLER algorithm. The algebraic systems obtained are solved by a conjugate gradient method. Results are reported in terms of isotherms, streamlines and average Nusselt number for Rayleigh number of 10^3–10^6. The contour lines show that the radiative effects are noted near the solid surfaces, and become increasingly important when the Rayleigh number increases. As a result, the rise in the value of Rayleigh number leads to an increase of the overall heat transfer within the greenhouse.

10/02784 Economic performance optimization of an absorption cooling system under uncertainty

Gebreslassie, B. H. *et al. Applied Thermal Engineering*, 2009, 29, (17–18), 3491–3500.

Many of the strategies devised so far to address the optimization of energy systems are deterministic approaches that rely on estimated data. However, in real world applications there are many sources of uncertainty that introduce variability into the decision-making problem. Within this general context, a novel approach is proposed to address the design of absorption cooling systems under uncertainty in the energy cost. As opposed to other approaches that optimize the expected performance of the system as a single objective, in this method the design task is formulated as a stochastic bi-criteria non-linear optimization problem that simultaneously accounts for the minimization of the expected total cost and the financial risk associated with the investment. The latter criterion is measured by the downside risk, which avoids the need to define binary variables thus improving the computational performance of the model. The capabilities of the proposed modelling framework and solution strategy are illustrated in a case study problem that addresses the design of a typical absorption cooling system. Numerical results demonstrate that the method presented allows to manage the risk level effectively by varying the area of the heat exchangers of the absorption cycle. Specifically, this strategy allows identifying the optimal values of the operating and design variables of the cycle that make it less sensitive to fluctuations in the energy price, thus improving its robustness in the face of uncertainty.

10/02785 Natural convective flows in a horizontal channel provided with heating isothermal blocks: effect of the inter blocks spacing

Bakkas, B. *et al. Energy Conversion and Management*, 2010, 51, (2), 296–304.

A numerical study of laminar steady natural convection induced in a two dimensional horizontal channel provided with rectangular heating blocks, periodically mounted on its lower wall, is carried out. The blocks' surface temperature, T'_H, is maintained constant and the former are connected with adiabatic surfaces. The upper wall of the channel is maintained cold at a temperature $T'_C > T'_H$. Fluid flow, temperature fields and heat transfer rates are presented for different combinations of the governing parameters which are the Rayleigh number ($10^2 \leq Ra \leq 2\times10^6$), the blocks' spacing ($1/4 \leq C = l'/H' \leq 1$), the blocks' height ($1/8 \leq B = h'/H' \leq 1/2$) and the relative width of the blocks ($A = (L' - l')/H' = 1/2$). The results obtained in the case of air ($Pr = 0.72$) show that the flow structure and the heat transfer are significantly influenced by the control parameters. It is found that there are situations where the increase of the blocks' spacing leads to a reduction of heat transfer.

10/02786 Performance analysis of a CO_2 heat pump water heating system under a daily change in a standardized demand

Yokoyama, R. *et al. Energy*, 2010, 35, (2), 718–728.

Air-to-water heat pumps using CO_2 as a natural refrigerant have been developed and commercialized. They are expected to contribute to energy saving in residential hot water supply. The objective of the research is to analyse the performance of a water heating system composed of a CO_2 heat pump and a hot water storage tank by numerical simulation. In this paper, the system performance is analysed under a daily change in a standardized hot water demand, and some features of the temperature distribution in the storage tank and the system performance criteria such as coefficient of performance, storage and system efficiencies, and volumes of stored and unused hot water are investigated. It turns out that the daily change in the hot water demand does not significantly affect the daily averages of the COP, and storage and system efficiencies, while it significantly affects not only the daily change in the volume of hot water unused after the tapping mode, but also that in the volume of hot water stored after the charging mode. The influence of the daily change in the hot water demand on the volumes of stored and unused hot water is clarified quantitatively.

10/02787 Performance enhancement in latent heat thermal storage system: a review

Jegadheeswaran, S. and Pohekar, S. D. *Renewable and Sustainable Energy Reviews*, 2009, 13, (9), 2225–2244.

Phase change material (PCM) based latent heat thermal storage (LHTS) systems offer a challenging option to be employed as an effective energy storage and retrieval device. The performance of LHTS systems is limited by the poor thermal conductivity of PCMs employed. Successful large-scale utilization of LHTS systems thus depends on the extent to which the performance can be improved. A great deal of work both experimental and theoretical on different performance enhancement techniques has been reported in the literature. This paper reviews the implementation of those techniques in different configurations of LHTS systems. The influence of enhancement techniques on the thermal response of the PCM in terms of phase change rate and amount of latent heat stored/retrieved has been addressed as a main aspect. Issues related to mathematical modelling of LHTS systems employing enhancement techniques are also discussed.

10/02788 Performance of a proposed complete wetting surface counter flow channel type liquid desiccant air dehumidifier

Hassan, M. S. and Hassan, A. A. M. *Renewable Energy*, 2009, 34, (10), 2107–2116.

An idea that improves the wettability over the surfaces of a cylindrical dehumidifier channel was proposed and experimentally proved. Fibrous sheets were attached to the inner surfaces of the channel. The capillary effect of fibbers sustains the complete wetting of the heat and mass transfer surfaces. The air to be dehumidified and cooled flows upward in the annulus space between the two layers of fibrous sheets, which are saturated with the downward flowing desiccant solution. The permeability of the fibrous sheet was determined experimentally. It was $2.43 \times 10^{-10}\,m^2$. The measured solution flow rate due to the capillary suction of the sheets was $\Gamma_{in,min} = 1.12$ kg/h m. The liquid desiccant tested was $H_2O/CaCl_2$ with salt concentration ratios ranging from 35 to 40%. The measured distribution of the solution flow rate along the circumference of the sheets at the outlet showed 5% deviation from the average flow rate. This is a good indication for the good wettability of walls inside the dehumidifier. Feeding the solution by this mechanism has many advantages over spray feeding. Beside sustaining complete surface wetting, it also prevents channel blockage with solution, which is a main factor in increasing the air pressure drop. About 95% of the air pressure drop is saved in this study by avoiding these problems. A simple theoretical model for the heat and mass transfer processes inside the dehumidifier was developed and experimentally validated. In general, there is good agreement between the predicted and measured data. The developed model was utilized to study the effect of the different parameters on the dehumidifier performance. For a 1 m height dehumidifier with an inlet specific humidity and air temperature of $0.0234\,kg_v/kg_a$, and 35 °C, respectively, the predicted outlet air specific humidity was $0.0102\,kg_v/kg_k$ and the corresponding outlet air temperature was 27.4 °C. The inlet solution temperature and salt concentration were 25 °C and 40%, respectively.

10/02789 Reducing heat transfer across the insulated walls of refrigerated truck trailers by the application of phase change materials

Ahmed, M. *et al. Energy Conversion and Management*, 2010, 51, (3), 383–392.

A general estimate shows that 80% of communities across the United States receive their goods exclusively by transport trucks, of which a significant number are climate-controlled because they carry perishable goods, pharmaceutical items and many other temperature-sensitive commodities. Keeping the inside of a truck trailer at a constant temperature and relative humidity requires exact amounts of heat and/or moisture management throughout the shipment period, which is regulated via small refrigeration units, placed outside the truck, that operate by burning fuel. These trucks, known as refrigerated truck trailers, are the focus of this paper. In the research presented herein, the conventional method of insulation of the refrigerated truck trailer was modified using phase change materials (PCMs). The limited research carried out in refrigerated transport compared to other refrigeration processes has left spaces for innovative solutions in this area. The research investigated the inclusion of paraffin-based PCMs in the standard trailer walls as a heat transfer reduction technology. An average reduction in peak heat transfer rate of 29.1% was observed when all walls (south, east, north, west, and top) were considered. For individual walls, the peak heat transfer rate was reduced in the range of 11.3–43.8%. Overall average daily heat flow reductions into the refrigerated compartment of 16.3% were observed. These results could potentially translate into energy savings, pollution abatement from diesel-burning refrigeration units, refrigeration equipment size reduction, and extended equipment operational life. The research and its results will help to better understand the scope of this technology.

10/02790 Reducing peak requirements for cooling by using thermally activated building systems

Rijksen, D. O. *et al. Energy and Buildings*, 2010, 42, (3), 298–304.

This paper presents general guidelines for the required cooling capacity of an entire office building using thermally activated building systems (TABS). By activating the thermal mass of the building using pipes embedded in the floor, peak loads can be reduced. On-site measurements were performed to obtain the required cooling power of an entire building as well as individual zones. Beside this, the internal climate conditions of rooms and surface temperatures of the TABS were measured. The measured data were used to analyse the predictive performance of a simulation model. In order to acquire general guidelines for the required cooling capacity of a standard office building, simulations of an entire building were used to determine the impact of variable internal heat gains and different sized windows. The required cooling capacity was compared to the cooling capacity of a system without energy buffering (e.g. chilled ceiling panels). It was found that reductions up to 50% of the cooling capacity for a chiller can be achieved using TABS. The presented results within this paper can be used as design guidelines in the first stage of a design process. The results focus on temperate climates and were derived using Dutch climate conditions.

10/02791 Reliability, availability and maintenance optimisation of heat exchanger networks

Sikos, L. and Klemeš, J. *Applied Thermal Engineering*, 2010, 30, (1), 63–69.

A new methodology is proposed to use comprehensive up-to-date commercial software tools for heat exchanger network (HEN) reliability modelling and optimization. The idea behind this proposal is that to apply the combination of specific HEN optimization and reliability software packages has several advantages over the commonly used approach. There is a variety of features that need to be taken into account to choose the right software tool. The HEN design has a significant impact on reliability issues and this should be considered. There are many related issues and features – the robustness, the type of welding, the increment of maximum mechanical resistance, the impact on manufacturing costs, reduction of lost opportunity costs caused by exchanger outages, troubleshooting of heating exchanger problems by operators etc. Fouling should be analysed as it has a significant impact on maintenance issues. Up to 30% decrease of maintenance costs can be achieved annually by applying advanced reliability results and determining heat exchanger failure causes. These analyses include the investigation of failure causes, prediction of future probabilities of failures, cleaning planning and scheduling and the calculation of reliability and maintainability.

10/02792 Solar assisted heat pump on air collectors: a simulation tool

Karagiorgas, M. *et al. Solar Energy*, 2010, 84, (1), 66–78.

The heating system of the bioclimatic building of the Greek National Centre for Renewable Energy Sources (CRES) comprises two heating plants: the first one includes an air source heat pump, solar air collectors (SACs) and a heat distribution system (comprising a fan coil unit network); the second one is, mainly, a geothermal heat pump unit to cover the ground floor thermal needs. The SAC configuration as well as the fraction of the building heating load covered by the heating plant are assessed in two operation modes; the direct (hot air from the collectors is supplied directly to the heated space) and the indirect mode (warm air from the SAC or its mixture with ambient air is not supplied directly to the heated space but indirectly into the evaporator of the air source heat pump). The technique of the indirect mode of heating aims at maximizing the efficiency of the SAC, saving electrical power consumed by the compressor of the heat pump, and therefore, at optimizing the coefficient of performance of the heat pump due to the increased intake of ambient thermal energy by means of the SAC. Results are given for three research objectives: assessment of the heat pump efficiency whether in direct or indirect heating mode; Assessment of the overall heating plant efficiency on a daily or hourly basis; Assessment of the credibility of the suggested simulation model TSAGAIR by comparing its results with the TRNSYS ones.

10/02793 Solar water heaters with phase change material thermal energy storage medium: a review

Shukla, A. *et al. Renewable and Sustainable Energy Reviews*, 2009, 13, (8), 2119–2125.

Latent heat thermal energy storage is one of the most efficient ways to store thermal energy for heating water by energy received from sun. This paper summarizes the investigation and analysis of thermal energy storage incorporating with and without phase change material (PCM) for use in solar water heaters. The relative studies are classified on the basis of type of collector and the type of storage used i.e. sensible or latent. A thorough literature investigation into the use of PCM in solar water heating has been considered. It has been demonstrated that for a better thermal performance of solar water heater a phase change material with high latent heat and with large surface area for heat transfer is required.

10/02794 Stationary vortices attached to flat roofs

Tryggeson, H. and Lyberg, M. D. *Journal of Wind Engineering and Industrial Aerodynamics*, 2010, 98, (1), 47–54.

This paper treats the topic of a conical vortex attached to a plane horizontal surface. Data have been collected from measurements on freely suspended cubes in a wind-tunnel. Data are analysed and some vortex properties derived. The pressure coefficient is found to decrease as the inverse of the square root of the distance from the corner. Experimental results are used to construct an analytical model of the conical flow derived from a solution to the non-linear vorticity transport equation and the resulting flow is predicted. This flow is used to calculate the pressure suction on the attached surface. An application would be pressure on flat roofs of high-rise buildings subjected to an adverse wind.

10/02795 Structural evaluation of a piping system subjected to thermal stratification

Chattopadhyay, S. *Nuclear Engineering and Design*, 2009, 239, (11), 2236–2241.

Piping systems in nuclear power plants are often designed for pressure, mechanical loads originating from deadweight and seismic events and operating thermal transients using the equations in the ASME Boiler and Pressure Vessel Code, Section III. In the last few decades a number of failures in piping have occurred due to thermal stratification caused by the mixing of hot and cold fluids under certain low flow conditions. Such stratified temperature fluid profiles give rise to circumferential metal temperature gradients through the pipe leading to high stresses causing fatigue damage. A simplified method has been developed in this work to estimate the stresses caused by the circumferential temperature distribution from thermal stratification. It has been proposed that the equation for the peak stress in the ASME Section III piping code include an additional term for thermal stratification.

10/02796 Study of an adsorption refrigeration system powered by parabolic trough collector and coupled with a heat pipe

El Fadar, A. *et al. Renewable Energy*, 2009, 34, (10), 2271–2279.

The aim of the current paper is to propose a study of a novel solar adsorptive cooling system, using activated carbon–ammonia pair, coupled with a parabolic trough collector and a water-stainless steel heat pipe. A theoretical model, based on the thermodynamics of the adsorption process, heat and mass transfer within the porous medium and energy balance in the hybrid system components, is developed and a simulation code, written in FORTRAN, is carried out. This model, which has been validated by experimentation results, computes the temperature, pressure and adsorbed mass inside the adsorbent bed. The performance is assessed in terms of specific cooling power and solar coefficient of performance (COPs). Furthermore, the effect of some important parameters on the system performance is discussed, and an optimization of these parameters is given. The simulation results have shown that there exists, for each aperture width value of the collector (W), an optimum external radius of adsorbent bed (R_2). Under the operating and design conditions of evaporation temperature $T_{\mathrm{ev}} = 0\,^{\circ}\mathrm{C}$, condensing temperature $T_{\mathrm{con}} = 28\,^{\circ}\mathrm{C}$, adsorption temperature $T_{\mathrm{ads}} = 24\,^{\circ}\mathrm{C}$, $W = 0.70\,\mathrm{m}$, $R_2 = 0.145\,\mathrm{m}$ and reactor length of 0.5 m, an optimal corresponding COPs is found to be of the order of 0.18.

10/02797 Thermal behaviour of an earth-sheltered autonomous building – the Brighton Earthship

Ip, K. and Miller, A. *Renewable Energy*, 2009, 34, (9), 2037–2043.

The benefits of reducing the thermal effect of global warming and structural damage by severe storms have renewed interest and drives to heavyweight constructions. One type of heavyweight construction using earth-sheltered construction known as an 'Earthship' has been developed and pioneered by US architect Michael Reynolds and recently introduced to the UK. The 'Earthship' takes on the concept of an 'independent vessel', which operates on a self-sufficient basis and is constructed largely from recycled and reclaimed materials. Although there are up to 3000 globally, only two Earthships have been built in the UK – one in Brighton and one in Scotland. The publicity resulting from the planning approval granted in April 2007 for the construction of sixteen domestic Earthships at the seafront of Brighton have raised public awareness to this type of unconventional construction. A key feature of the Earthship design is the use of a thermal store, which acts as a seasonal heat buffer to absorb heat in the summer and to release heat in the winter, to regulate the room temperature. This paper reports on the initial findings of a long-term study on the thermal behaviour of the thermal store and its effect to the indoor environment. It introduces the design and construction principles of the Earthship and outlines the process and equipment used in the thermal monitoring of the building. Indicative results from the analyses of the data collected at the early stage are reported and discussed. Initial findings have demonstrated the effectiveness of the thermal charging and discharging of the earth-rammed thermal mass, which appeared to moderate the extreme external temperatures.

10/02798 Thermal comfort in naturally ventilated apartments in summer: findings from a field study in Hyderabad, India

Indraganti, M. *Applied Energy*, 2010, 87, (3), 866–883.

There is little thermal comfort research in residential environments reported from India. Energy consumption in Indian residential buildings is one of the highest, increasing at a phenomenal rate. Indian standards advocate two narrow ranges of temperatures for all building and climate types. In this context, a field study in summer and monsoon was conducted following Class-II protocols, for three months in 2008, in naturally ventilated apartment buildings in Hyderabad. Over a 100 subjects involved, giving 3962 datasets. In May, most of the subjects were uncomfortable, preferring a temperature on the cooler side of the neutrality, despite accepting their thermal environments. Thermal sensation, preference and acceptance improved in June and July as temperature receded. Humidity did not affect comfort sensation much, as summer was hot and dry. Conversely, increase in humidity adversely affected the thermal comfort in June. Adaptive use of controls resulted in moderate air movement indoors, adequate for sweat evaporation most of the time. The subjects used traditional ensembles and slowed down their activities adaptively to restore thermal comfort. Clothing adaptation was found to be impeded by many socio-cultural and economic aspects. The comfort band (voting within −1 and +1) based on the regression analysis was found to be 26–32.45 °C with the neutral temperature at 29.23 °C. This is way above the limits (23–26 °C) set by Indian standards. The PMV was always found to be higher than the actual sensation vote. These findings have far reaching energy implications in a developing country like India.

11 ENGINES

Power generation and propulsion, electrical vehicles

10/02799 A novel linear switched reluctance motor for railway transportation systems

Daldaban, F. and Ustkoyuncu, N. *Energy Conversion and Management*, 2010, 51, (3), 465–469.

This paper presents the design and realization of a new linear switched reluctance motor (LSRM) structure, especially suitable for high-speed railway systems. The new model has a double active stator configuration and provides high force for many applications with low cost. The characteristics of the LSRM are obtained by using finite element analysis (FEA) and analytical calculations. The results of the FEA and analytical calculations are presented, and compared with experimental results. In addition, a classical double-sided LSRM (DSLSRM) is modelled with the same specifications of the new motor structure and the results are compared.

10/02800 Analysis of repeatability of Diesel engine acceleration

Litak, G. and Longwic, R. *Applied Thermal Engineering*, 2009, 29, (17–18), 3574–3578.

The analysis of combustion non-repeatability in the dynamical working conditions of a Diesel engine is presented. In the frame of statistical analysis, applied to a number of acceleration trails, basic determinants such as standard square deviation, skewness, and kurtosis have been calculated for the mean indicated pressure. The methods of return maps, delay phase portrait reconstruction, recurrence plots and quantification recurrence analysis have been also used to analyse a single chosen course of the measured pressure starting from the idle run of engine, through its acceleration process and ending on a stable engine run with a certain velocity. The results show that recurrence techniques are able to identify various phases of the engine non-stationary work.

10/02801 Assessment of oxyfuel power generation technologies

Hadjipaschalis, I. *et al. Renewable and Sustainable Energy Reviews*, 2009, 13, (9), 2637–2644.

In this work, a cost–benefit analysis concerning the use of oxyfuel combustion technology is carried out. For the analysis, the IPP optimization software is used in which a decouple optimization method for power technology selection in competitive markets is employed and the electricity unit cost and the CO_2 avoidance cost are calculated. The results indicate that oxyfuel technology is a competitive CO_2 capture and storage (CCS) technology. In addition, the effect of varying loan interest rates was investigated in the economic performance of an oxyfuel combustion plant. This analysis, revealed that up to a value of loan interest of approximately 5.3% the oxyfuel plant retains the competitive electricity unit costs (compared to other CCS technologies). For higher interest rate levels, other CCS technologies become more economically attractive.

10/02802 Axial flow, multi-stage turbine and compressor models

Tournier, J.-M. and El-Genk, M. S. *Energy Conversion and Management*, 2010, 51, (1), 16–29.

Design models of multi-stage, axial-flow turbine and compressor are developed for high temperature nuclear reactor power plants with closed Brayton cycle for energy conversion. The models are based on a mean-line through-flow analysis for free-vortex flow, account for the profile, secondary, end wall, trailing edge and tip clearance losses in the cascades, and calculate the geometrical parameters of the blade cascades. The effects of the mean-stage work coefficient, flow coefficient and stage reaction on the design and performance of helium turbine and compressor are investigated. The results compare favourably with those reported for a six-stage helium turbine and a 20-stage helium compressor. Also presented and discussed are the results of parametric analyses of a 530-MW helium turbine, and a 251-MW helium compressor.

10/02803 Performance of a beta-configuration heat engine having a regenerative displacer

Eid, E. *Renewable Energy*, 2009, 34, (11), 2404–2413.

This paper investigates the performance of a beta-configuration heat engine having a regenerative displacer. In the conventional beta-engine; the displacer and the power piston are incorporated in one cylinder. The displacer transfers the working fluid between expansion and compression spaces via the heater, the regenerator, and the cooler. In the present work, successive homogeneous layers of square wire meshes occupy the displacer space of a beta-engine that make the displacer to be a displacer and a regenerator simultaneously. The theoretical analysis of the engine is based mainly on Schmidt theory. The optimum dimensions of the heater, cooler, regenerator, piston stroke and displacer stroke as dimensionless ratios of the bore were found. The optimum phase angle between the piston and the displacer and the optimum ranges of the speed for each working gas were also found. In a comparison between the proposed engine which has a regenerative displacer and the GPU-3 engine which has a stationary regenerator and a solid displacer; it was found that; the proposed one delivers 20% more power with 10% more efficiency than the GPU-3 engine.

10/02804 Variable geometry gas turbines for improving the part-load performance of marine combined cycles – gas turbine performance

Haglind, F. *Energy*, 2010, 35, (2), 562–570.

The part-load performance of gas and steam turbine combined cycles intended for naval use is of great importance, and it is influenced by the gas turbine configuration and load control strategy. This paper is aimed at quantifying the effects of variable geometry on the gas turbine part-load performance. Subsequently, in another paper, the effects of variable geometry on the part-load performance for combined cycles used for ship propulsion will be presented. Moreover, this paper is aimed at developing methodologies and deriving models for part-load simulations suitable for energy system analysis of various components within gas turbines. Two different gas turbine configurations are studied, a two-shaft aero-derivative configuration and a single-shaft industrial configuration. When both gas turbine configurations are running in part-load using fuel flow control, the results indicate better part-load performance for the two-shaft gas turbine. Reducing the load this way is accompanied by a much larger decrease in exhaust gas temperature for the single-shaft gas turbine than for the two-shaft configuration. As used here, the results suggest that variable geometry generally deteriorates the gas turbine part-load performance.

Hybrid engine systems

10/02805 6BTA 5.9 G2–1 Cummins engine performance and emission tests using methyl ester mahua (*Madhuca indica*) oil/diesel blends

Godiganur, S. *et al. Renewable Energy*, 2009, 34, (10), 2172–2177.

Neat mahua oil poses some problems when subjected to prolonged usage in CI engine. The transesterification of mahua oil can reduce these problems. The use of biodiesel fuel as substitute for conventional petroleum fuel in heavy-duty diesel engine is receiving an increasing amount of attention. This interest is based on the properties of biodiesel including the fact that it is produced from a renewable resource, its biodegradability and potential to exhaust emissions. A Cummins 6BTA 5.9 G2-1, 158 HP rated power, turbocharged, DI, water cooled diesel engine was run on diesel, methyl ester of mahua oil and its blends at constant speed of 1500 rpm under variable load conditions. The volumetric blending ratios of biodiesel with conventional diesel fuel were set at 0, 20, 40, 60, and 100. Engine performance (brake specific fuel consumption, brake specific energy consumption, thermal efficiency and exhaust gas temperature) and emissions (CO, HC and NO_x) were measured to evaluate and compute the behaviour of the diesel engine running on biodiesel. The results indicate that with the increase of biodiesel in the blends CO, HC reduces significantly, fuel consumption and NO_x emission of biodiesel increases slightly compared with diesel. Brake specific energy consumption decreases and thermal efficiency of engine slightly increases when operating on 20% biodiesel than that operating on diesel.

10/02806 Alternative fuel and gasoline in an SI engine: a comparative study of performance and emissions characteristics

Pourkhesalian, A. M. *et al. Fuel*, 2010, 89, (5), 1056–1063.

The strict regulation of environmental laws, the price of oil and its restricted resources, has made engine manufacturers use other energy resources instead of oil and its products. Despite the fact that nowadays alternative fuels are not currently widely used in vehicular applications, using these kinds of fuels will be definitely inevitable in the future. In this paper, a computer code is developed in Matlab environment and then its results are validated with experimental data. This simulated engine model could be used as an powerful tool to investigate the performance and emission of a given SI engine fuelled by alternative fuels including hydrogen, propane, methane, ethanol and methanol. Also, the superior of alternative fuels is shown by comparing the performance and emissions of alternative fuelled engines to those in conventional fuelled engines. Eventually, it is concluded that volumetric efficiency of the engine working on hydrogen is the lowest (28% less that gasoline fuelled engine), gasoline produce more power than the all being tested alternative fuels and BSFC of methanol is 91% higher than that of gasoline while BSFC of hydrogen is 63% less than gasoline.

10/02807 Combustion and performance evaluation of a diesel engine fueled with biodiesel produced from soybean crude oil

Qi, D. H. *et al. Renewable Energy*, 2009, 34, (12), 2706–2713.

In this study, the biodiesel produced from soybean crude oil was prepared by a method of alkaline-catalysed transesterification. The important properties of biodiesel were compared with those of diesel. Diesel and biodiesel were used as fuels in the compression ignition engine, and its performance, emissions and combustion characteristics of the engine were analysed. The results showed that biodiesel exhibited the similar combustion stages to that of diesel, however, biodiesel showed an earlier start of combustion. At lower engine loads, the peak cylinder pressure, the peak rate of pressure rise and the peak of heat release rate during premixed combustion phase were higher for biodiesel than for diesel. At higher engine loads, the peak cylinder pressure of biodiesel was almost similar to that of diesel, but the peak rate of pressure rise and the peak of heat release rate were lower for biodiesel. The power output of biodiesel was almost identical with that of diesel. The brake specific fuel consumption was higher for biodiesel due to its lower heating value. Biodiesel provided significant reduction in CO, HC, NO_x and smoke under speed characteristic at full engine load. Based on this study, biodiesel can be used as a substitute for diesel in diesel engine.

10/02808 Energy system feasibility study of an Otto cycle/Stirling cycle hybrid automotive engine

Cullen, B. and McGovern, J. *Energy*, 2010, 35, (2), 1017–1023.

The aim of this study was to investigate the feasibility of utilizing a Stirling cycle engine as an exhaust gas waste heat recovery device for an Otto cycle internal combustion engine (ICE) in the context of an automotive power plant. The hybrid arrangement would produce increased brake power output for a given fuel consumption rate when compared to an ICE alone. The study was dealt with from an energy system perspective with design practicalities such as power train integration, location of auxiliaries, manufacture costs and other general plant design considerations neglected. The study necessitated work in two distinct areas: experimental assessment of the performance characteristics of an existing automotive Otto cycle ICE and mathematical modelling of the Stirling cycle engine based on the output parameters of the ICE. It was subsequently found to be feasible in principle to generate approximately further 30% useful power in addition to that created by the ICE by using a Stirling cycle engine to capture waste heat expelled from the ICE exhaust gases over the complete range of engine operating speeds.

10/02809 Performance analysis of a pressurized molten carbonate fuel cell/micro-gas turbine hybrid system

Liu, A. and Weng, Y. *Journal of Power Sources*, 2010, 195, (1), 204–213.

This paper presents the work on the design and part-load operations of a hybrid power system composed of a pressurized molten carbonate fuel cell (MCFC) and a micro-gas turbine (MGT). The gas turbine is an existing one and the MCFC is assumed to be newly designed for the hybrid system. Firstly, the MCFC power and total system power are determined based on the existing micro-gas turbine according to the appropriate MCFC operating temperature. The characteristics of hybrid system on design point are shown. And then different control methods are applied to the hybrid system for the part-load operation. The effect of different control methods is analysed and compared in order to find the optimal control strategy for the system. The results show that the performance of hybrid system during part-load operation varies significantly with different control methods. The system has the best efficiency when using variable rotational speed control for the part-load operation. At this time both the turbine inlet temperature and cell operating temperature are close to the design value, but the compressor would cross the surge line when the shaft speed is less than 70% of the design shaft speed. For the gas turbine it is difficult to obtain the original power due to the higher pressure loss between compressor and turbine.

10/02810 Performance and emission evaluation of a CI engine fueled with preheated raw rapeseed oil (RRO)–diesel blends

Hazar, H. and Aydin, H. *Applied Energy*, 2010, 87, (3), 786–790.

Many studies are still being carried out to find out surplus information about how vegetable based oils can efficiently be used in compression ignition engines. Raw rapeseed oil (RRO) was used as blended with diesel fuel (DF) by 50% oil–50% diesel fuel in volume (O50) also as blended with diesel fuel by 20% oil–80% diesel fuel in volume (O20). The test fuels were used in a single cylinder, four stroke, naturally aspirated, direct injection compression ignition engine. The effects of fuel preheating to 100 °C on the engine performance and emission characteristics of a CI engine fuelled with rapeseed oil diesel blends were clarified. Results showed that preheating of RRO was lowered RRO's viscosity and provided smooth fuel flow Heating is necessary for smooth flow and to avoid fuel filter clogging. It can be achieved by heating RRO to 100 °C. It can also be concluded that preheating of the fuel have some positive effects on engine performance and emissions when operating with vegetable oil.

10/02811 Regulated and unregulated emissions from a diesel engine fueled with biodiesel and biodiesel blended with methanol

Cheung, C. S. *et al. Atmospheric Environment*, 2009, 43, (32), 4865–4872.

Experiments were carried out on a diesel engine operating on Euro V diesel fuel, pure biodiesel and biodiesel blended with methanol. The blended fuels contain 5%, 10% and 15% by volume of methanol. Experiments were conducted under five engine loads at a steady speed of $1800\,\mathrm{rev\,min^{-1}}$ to assess the performance and the emissions of the engine associated with the application of the different fuels. The results indicate an increase of brake specific fuel consumption and brake thermal efficiency when the diesel engine was operated with biodiesel and the blended fuels, compared with the diesel fuel. The blended fuels could lead to higher CO and HC emissions than biodiesel, higher CO emission but lower HC emission than the diesel fuel. There are simultaneous reductions of NO_x and PM to a level below those of the diesel fuel. Regarding the unregulated emissions, compared with the diesel fuel, the blended fuels generate higher formaldehyde, acetaldehyde and unburned methanol emissions, lower 1,3-butadiene and benzene emissions, while the toluene and xylene emissions not significantly different.

10/02812 Targeting plug-in hybrid electric vehicle policies to increase social benefits

Skerlos, S. J. and Winebrake, J. J. *Energy Policy*, 2010, 38, (2), 705–708.

In 2009 the US federal government enacted tax credits aimed at encouraging consumers to purchase plug-in hybrid electric vehicles (PHEVs). These tax credits are available to all consumers equally and therefore do not account for the variability in social benefits associated with PHEV operation in different parts of the country. The tax credits also do not consider variability in consumer income. This paper discusses why the PHEV subsidy policy would have higher social benefits at equal or less cost if the tax credits were offered at different levels depending on consumer income and the location of purchase. Quantification of these higher social benefits and related policy proposals are left for future work.

10/02813 The effects of ethanol–unleaded gasoline blends on engine performance and exhaust emissions in a spark-ignition engine

Koç, M. *et al. Renewable Energy*, 2009, 34, (10), 2101–2106.

Alcohols have been used as a fuel for engines since 19th century. Among the various alcohols, ethanol is known as the most suited renewable, bio-based and ecofriendly fuel for spark-ignition (SI) engines. The most attractive properties of ethanol as an SI engine fuel are that it can be produced from renewable energy sources such as sugar, cane, cassava, many types of waste biomass materials, corn and barley. In addition, ethanol has higher evaporation heat, octane number and flammability temperature therefore it has positive influence on engine performance and reduces exhaust emissions. In this study, the effects of unleaded gasoline (E0) and unleaded gasoline–ethanol blends (E50 and E85) on engine performance and pollutant emissions were investigated experimentally in a single cylinder four-stroke spark-ignition engine at two compression ratios (10:1 and 11:1). The engine speed was changed from 1500 to 5000 rpm at wide open throttle (WOT). The results of the engine test showed that ethanol addition to unleaded gasoline increase the engine torque, power and fuel consumption and reduce carbon monoxide (CO), nitrogen oxides (NO_x) and hydrocarbon (HC) emissions. It was also found that ethanol–gasoline blends allow increasing compression ratio (CR) without knock occurrence.

Transport battery development

10/02814 A lithium-air battery with a potential to continuously reduce O_2 from air for delivering energy

Wang, Y. and Zhou, H. *Journal of Power Sources*, 2010, 195, (1), 358–361.

A lithium-air battery, in which the catalytic reduction of O_2 in an alkaline aqueous electrolyte and the metallic lithium in a non-aqueous electrolyte were subtly united together by a super-ionic conductor glass film (LISICON), was established in the present work. For this system, Mn_3O_4 based air diffusion electrode and metallic lithium were used as positive electrode and negative electrode, respectively. 500 h continuous discharge performance indicates that this kind of lithium-air battery has a potential to realize continuous reduction of O_2 from air to deliver energy like a fuel cell. During the long-time discharge process, the air electrode has delivered a special capacity of 50,000 mAh g^{-1} based on total mass of catalytic electrode (carbon + binder + catalyst). This result is much higher than that of previous studies about Lithium-air batteries.

10/02815 Comparative analysis of battery electric, hydrogen fuel cell and hybrid vehicles in a future sustainable road transport system

Offer, G. J. *et al. Energy Policy*, 2010, 38, (1), 24–29.

This paper compares battery electric vehicles (BEV) to hydrogen fuel cell electric vehicles (FCEV) and hydrogen fuel cell plug-in hybrid vehicles (FCHEV). Qualitative comparisons of technologies and infrastructural requirements, and quantitative comparisons of the lifecycle cost of the powertrain over 100,000 mile are undertaken, accounting for capital and fuel costs. A common vehicle platform is assumed. The 2030 scenario is discussed and compared to a conventional gasoline-fuelled internal combustion engine (ICE) powertrain. A comprehensive sensitivity analysis shows that in 2030 FCEVs could achieve lifecycle cost parity with conventional gasoline vehicles. However, both the BEV and FCHEV have significantly lower lifecycle costs. In the 2030 scenario, powertrain lifecycle costs of FCEVs range from $7360 to $22,580, whereas those for BEVs range from $6460 to $11,420 and FCHEVs, from $4310 to $12,540. All vehicle platforms exhibit significant cost sensitivity to powertrain capital cost. The BEV and FCHEV are relatively insensitive to electricity costs but the FCHEV and FCV are sensitive to hydrogen cost. The BEV and FCHEV are reasonably similar in lifecycle cost and one may offer an advantage over the other depending on driving patterns. A key conclusion is that the best path for future development of FCEVs is the FCHEV.

10/02816 Effects of Ni substitution on the properties of Co_3O_4/graphite composites as anode of lithium ion batteries

Guo, H.-J. *et al. Energy Conversion and Management*, 2010, 51, (2), 247–252.

Ni-substituted Co_3O_4/graphite composites were synthesized by precipitation of cobalt oxalate and nickel oxalate on the surface of graphite and pyrolysis of the precipitate. The effects of nickel content and calcination temperature on the properties of the composites were investigated. The samples were characterized by thermogravimetry and differential thermal analysis (TG/DTA), X-ray diffraction (XRD), scanning electron microscope (SEM), cyclic voltammetry (CV) and charge/discharge measurements. The composites consist of graphite and a face-centred cubic (fcc) Co_3O_4 phase of fd3m space group, and there is no diffraction peaks associated with nickel compounds. Mild nickel substitution can improve the reversible capacity of the Co_3O_4/graphite composite. With increasing the calcination temperature from 300 to 500 °C, the reversible capacity of the composites with 10% Ni substitution increases from 641 to 874 mA h g^{-1}. The composite synthesized at 400 °C shows an initial reversible capacity of 690 mA h g^{-1} and excellent cycling stability.

12 REFRACTORIES/ CERAMICS

Properties, production, applications

10/02817 An empirical model for angle-dependent *g*-values of glazings

Singh, M. C. and Garg, S. N. *Energy and Buildings*, 2010, 42, (3), 375–379.

An empirical relation, to determine *g*-values of glazing at oblique angles of incidence, has been determined. The requirements of the model are: *g*(*o*), *g*-value at normal incidence and number of panes in the glazing. The effect of glazing type (clear, tinted or coated), thickness of glass and the number of panes, appear in *g*(*o*). At off-normal incidence, *g*-value is determined by number of panes in the glazing. Fresnel equations are used to calculate *g*-values at different angles of incidence and these values are treated as 'exact'. These calculations involve optical constants of each glazing (spectral refractive indices and spectral extinction coefficients) and then an empirical fit is found. The present model is compared to other three models, namely Monolithic model, Montecchi model and Karlsson model. The study includes nine types of glazing like clear, tinted and coated glass.

10/02818 Conductive ceramic coating on polyacrylonitrile–vinyl chloride (modacrylic) discontinuous fibers via electroless deposition

Patankar, S. N. *et al. Journal of Power Sources*, 2010, 195, (1), 362–366.

Lead dioxide has electrical conductivity that is comparable to that of some of the metals. Like copper and nickel, lead dioxide can be deposited on non-conducting materials, for example, polymers and ceramics, using spontaneous and low-cost deposition techniques such as electroless deposition. This paper deals with the development of conductive modacrylic fibres by coating them with lead dioxide via electroless deposition. These fibres will be used as additives in the lead-acid battery to improve its life and specific energy.

10/02819 Debinding behaviors of injection molded ceramic bodies with nano-sized pore channels during extraction using supercritical carbon dioxide and n-heptane solvent

Kim, S. W. *The Journal of Supercritical Fluids*, 2010, 51, (3), 339–344.

Debinding behaviours related on changes in capillary pore structure during extraction with supercritical carbon dioxide and n-heptane, respectively were investigated for injection moulded ceramic bodies consisting of skeleton pores of 68 nm. For the debinding processes, both debinding curves showed a square root of time dependence but significantly deviated in the middle or end period of debinding because of structural changes with pores during extraction. The debinding bodies experienced capillary changes having a debinding front separating the undebinded region with fluid state into the debinding region with pendular state in the wax-based green bodies. The debinding rate of the supercritical fluid extraction was five times higher than that of the solvent extraction because of a higher interdiffusion diffusivity and a formation of relatively large pore channels. An abrupt change of pore structures between debinded and undebinded region in the green bodies caused severe defects during the solvent extraction even at a low rate of debinding at 313.15 K, while the severity of the capillary changes was overcome during the supercritical fluid extraction and the debinded ceramic bodies were free from defects even at a high rate of debinding at 328.15 K. It is attributed to a reduction of the capillary stress developed on debinding front during the supercritical fluid extraction.

10/02820 Durability of clay roofing tiles: the influence of microstructural and compositional variables

Raimondo, M. *et al. Journal of the European Ceramic Society*, 2009, 29, (15), 3121–3128.

The frost behaviour of 13 industrially manufactured roofing tiles was assessed through a double approach: performing severe freeze/thaw testing (EN 539–2) and calculating durability indices, according to models present in the literature. The products microstructure was fully investigated in terms of physical, technological and compositional parameters, and the results correlated with the frost resistance of roofing tiles. No prediction model was able to reliably foresee the product performances; in particular, the correspondence with the excellent experimental behaviour of the most resistant samples is lacking. Coupling microstructural with compositional variables, new indications came out concerning the design and production of roofing tiles able to withstand adverse climatic conditions. If, once again, bulk density can be considered as the most influent parameter (highest values involve an improved durability), the production of roofing tiles with excellent frost resistance involves also the evaluation of an increased number of product (i.e. raw materials composition, microstructure and phase composition) and processing (i.e. firing temperature) variables.

10/02821 Numerical simulation of the effect of the Al molar fraction and thickness of an Al_xGa_{1-x} As window on the sensitivity of a p^+–n–n^+ GaAs solar cell to 1 MeV electron irradiation

Meftah, A. F. *et al. Renewable Energy*, 2009, 34, (11), 2426–2431.

In this paper numerical simulation has been used to predict the effect of the thickness and aluminium (Al) mole fraction of an AlGaAs layer, used as a window for a p^+–n–n^+ GaAs solar cell under AM0 illumination and exposed to 1 MeV electron irradiation. Such solar cells are used in satellites and undergo severe degradation in their performance due to induced structural defects. The irradiation-induced defects are modelled as energy levels in the energy gap of GaAs. To predict this effect, the spectral response is evaluated for different electron irradiation fluences for two types of cells. In the first a narrow $Al_{0.31}Ga_{0.69}As$ window is a small part of the p^+ layer while in the second type the whole window is an $Al_xGa_{1-x}As$ layer with a gradual Al mole fraction. The obtained results show that the $Al_xGa_{1-}xAs$ window with a gradual Al mole fraction improves the resistance of the solar cell to electron irradiation especially in the short wavelengths range.

10/02822 Processing of transparent glass-ceramics by nanocrystallisation of LaF_3

Hémono, N. *et al. Journal of the European Ceramic Society*, 2009, 29, (14), 2915–2920.

Transparent glass-ceramics have been prepared by heat-treating oxyfluoride glasses in the Na_2O–Al_2O_3–SiO_2–LaF_3 system. The nanocrystallization of LaF_3 was achieved by controlling time and temperature parameters. Glasses and glass-ceramics were characterized by dilatometry, DTA, XRD and TEM. The mean crystal size (<20 nm) and the crystal fraction increase with the temperature of heat treatment, while they reach a maximum at about 20 h at a temperature close to T_g. The crystallization of phases containing glass modifier elements as well as F anions leads to the increase in the viscosity of the remaining glass matrix. Phase separation occurs in glass-ceramics depending on the glass composition which affects nanocrystallization.

10/02823 Solution precursor high-velocity oxy-fuel spray ceramic coatings

Chen, D. *et al. Journal of the European Ceramic Society*, 2009, 29, (16), 3349–3353.

For the first time, the solution precursor high-velocity oxy-fuel spray process was used to deposit Al_2O_3–ZrO_2 ceramic coatings. X-ray diffraction analysis and transmission electron microscopy characterization show that the as-sprayed coating is composed of mixed nanocrystalline ZrO_2 and γ-Al_2O_3 as well as amorphous phases. The as-sprayed coating consists of ultrafine splats with diameters ranging from 2 to 5 µm. Few spherical particles, hollow-shell structures are also observed on the coating surface. Polished cross-section shows that the coating is quite dense with a thickness of 40 µm.

10/02824 Structural investigations of borosilicate glasses containing MoO_3 by MAS NMR and Raman spectroscopies

Caurant, D. *et al. Journal of Nuclear Materials*, 2010, 396, (1), 94–101.

High molybdenum concentration in glass compositions may lead to alkali and alkaline-earth molybdates crystallization during melt cooling that must be controlled particularly during the preparation of highly radioactive nuclear glassy waste forms. To understand the effect of molybdenum addition on the structure of a simplified nuclear glass and to know how composition changes can affect molybdates crystallization tendency, the structure of two glass series belonging to the SiO_2–B_2O_3–Na_2O–CaO–MoO_3 system was studied by ^{29}Si, ^{11}B, ^{23}Na MAS NMR and Raman spectroscopies by increasing MoO_3 or B_2O_3 concentrations. Increasing MoO_3 amount induced an increase of the silicate network reticulation but no significant effect was observed on the proportion of units and on the distribution of Na^+ cations in glass structure. By increasing B_2O_3 concentration, a strong evolution of the distribution of Na^+ cations was observed that could explain the evolution of the nature of molybdate crystals ($CaMoO_4$ or Na_2MoO_4) formed during melt cooling.

10/02825 Thermal stability of a new solid oxide fuel/electrolyzer cell seal glass

Jin, T. and Lu, K. *Journal of Power Sources*, 2010, 195, (1), 195–203.

Long-term thermal stability of sealing glass is critical for hermetic seals of solid oxide fuel and electrolyser cell stacks. In this work, a SrO–La_2O_3–Al_2O_3–SiO_2 glass (SABS-0 glass) has been evaluated as a high temperature sealant by thermal treatment. Powder and bulk SABS-0 glasses are studied in both air and H_2/H_2O atmospheres at 800 °C for up to 1000 h. Weight measurements show negligible SABS-0 glass vaporization during the thermal treatment. Both SABS-0 powder and bulk samples show some surface devitrification but the SABS-0 glass bulk remains amorphous at all the thermal treatment conditions. On the polished bulk SABS-0 surface, needle-shaped crystals are observed for both the air and the H_2/H_2O thermal treatment conditions. Polishing is believed to be the initiator for the SABS-0 glass surface devitrification. The crystalline phases, identified as silicates and aluminates, increase with the thermal treatment time. However, the crystalline phases on the polished SABS-0 glass surface are very limited and only exist on the very surface of both the air and the H_2/H_2O atmosphere treated samples. The SABS-0 glass has excellent thermal stability in solid oxide fuel/electrolyser operating environments and is a promising sealant material for such applications.

10/02826 Valorisation of wastewater from two-phase olive oil extraction in fired clay brick production

de la Casa, J. A. *et al. Journal of Hazardous Materials*, 2009, 169, (1–3), 271–278.

Wastewater issued from oil-washing stage (OWW) in the two-phase olive oil extraction method was used to replace fresh water in clay brick manufacture. The extrusion trials were performed with one of the ceramic bodies currently being used in a local brick factory for red facing bricks (RB) production. Fresh water or OWW was added to a final consistency of 2.4 kg/cm^2, the same value as used at industrial scale for this kind of clay mixture. Comparative results of technological properties of facing bricks are presented. Results show that the products obtained with olive oil wastewater are comparable to traditional ones in terms of extrusion performance and technological properties of end products. Even dry-bending strength of the body formed by wastewater improves by 33% compared to fresh water body. In addition, heating requirements can be reduced in the range 2.4–7.3% depending on the final product. This application can alleviate environmental impacts from the olive oil extraction industry and, at the same time, result in economic savings for the brick manufacturing industry.

13 ALTERNATIVE ENERGY SUPPLIES

Biofuels and bioconversion energy

10/02827 An overview of the chemical composition of biomass

Vassilev, S. V. *et al. Fuel*, 2010, 89, (5), 913–933.

An extended overview of the chemical composition of biomass was conducted. The general considerations and some problems related to biomass and particularly the composition of this fuel are discussed. Reference peer-reviewed data for chemical composition of 86 varieties of biomass, including traditional and complete proximate, ultimate and ash analyses (21 characteristics), were used to describe the biomass system. It was shown that the chemical composition of biomass and especially ash components are highly variable due to the extremely high variations of moisture, ash yield, and different genetic types of inorganic matter in biomass. However, when the proximate and ultimate data are recalculated respectively on dry and dry ash-free basis, the characteristics show quite narrow ranges. In decreasing order of abundance, the elements in biomass are commonly C, O, H, N, Ca, K, Si, Mg, Al, S, Fe, P, Cl, Na, Mn, and Ti. It was identified that the chemical distinctions among the specified natural and anthropogenic biomass groups and sub-groups are significant and they are related to different biomass sources and origin, namely from plant and animal products or from mixtures of plant, animal, and manufacture materials. Respective chemical data for 38 solid fossil fuels were also applied as subsidiary information for clarifying the biomass composition and for comparisons. It was found that the chemical composition of natural biomass system is simpler than that of solid fossil fuels. However, the semi-biomass system is quite complicated as a result of incorporation of various non-biomass materials during biomass processing. It was identified that the biomass composition is significantly different from that of coal and the variations among biomass composition were also found to be greater than for coal. Natural biomass is: (1) highly enriched in Mn > K > P > Cl > Ca > (Mg, Na) > O > moisture > volatile matter; (2) slightly enriched in H; and (3) depleted in ash, Al, C, Fe, N, S, Si, and Ti in comparison with coal. The correlations and associations among 20 chemical characteristics are also studied to find some basic trends and important relationships occurring in the natural biomass system. As a result of that five strong and important associations, namely: (1) C–H; (2) N–S–Cl; (3) Si–Al–Fe–Na–Ti; (4) Ca–Mg–Mn; and (5) K–P–S–Cl; were identified and discussed. The potential applications of these associations for initial and preliminary classification, prediction and indicator purposes related to biomass were also introduced or suggested. However, future detailed data on the phase–mineral composition of biomass are required to explain actually such chemical trends and associations.

10/02828 Bio-fuels production and the environmental indicators

de Paula Gomes, M. S. and de Araújo, S. M. *Renewable and Sustainable Energy Reviews*, 2009, 13, (8), 2201–2204.

The paper evaluates the role of the bio-fuels production in the transportation sector in the world, for programs of greenhouse gases emissions reductions and sustainable environmental performance. Depending on the methodology used to account for the local pollutant emissions and the global greenhouse gases emissions during the production and consumption of both the fossil and bio-fuels, the results can show huge differences. If it is taken into account a life cycle inventory approach to compare the different fuel sources, these results can present controversies. A comparison study involving the American oil diesel and soybean diesel developed by the National Renewable Energy Laboratory presents CO_2 emissions for the bio-diesel which are almost 20% of the emissions for the oil diesel: 136 g CO_2/bhp-h for the bio-diesel from soybean and 633 g CO_2/bhp-h for the oil diesel [National Renewable Energy Laboratory – NREL/SR-580–24089]. Besides that, important local environmental impacts can also make a big difference. The water consumption in the soybean production is much larger in comparison with the water consumption for the diesel production. Brazil has an important role to play in this scenario because of its large experience in bio-fuels production since the seventies, and the country has conditions to produce bio-fuels for attending great part of the world demand in a sustainable pathway.

10/02829 Bio-methanization of energy crops through mono-digestion for continuous production of renewable biogas

Demirel, B. and Scherer, P. *Renewable Energy*, 2009, 34, (12), 2940–2945.

The aim of this laboratory-scale study was to investigate the long-term anaerobic fermentation of an extremely sour substrate, an energy crop, for continuous production of methane (CH_4) as a source of renewable energy. The sugar beet silage was used as the mono-substrate, which had a low pH of around 3.3–3.4, without the addition of manure. The mesophilic biogas digester was operated in a hydraulic retention time (HRT) range between 15 and 9.5 days, and an organic loading rate (OLR) range of between 6.33 and $10\,g\ VS\,l^{-1}\,d^{-1}$. The highest specific gas production rate (spec. GPR) and CH_4 content were $0.671\,g\ VS^{-1}\,d^{-1}$ and 74%, respectively, obtained at an HRT of 9.5 days and OLR of $6.35\,g\ VS\,l^{-1}\,d^{-1}$. The digester worked within the neutral pH range as well. Since this substrate lacked the availability of macro and micro nutrients, and the buffering capacity as well, external supplementation was definitely required to provide a stable and efficient operation, as provided using NH_4Cl and $KHCO_3$ in this case. The findings of this ongoing long-term fermentation of an extremely acidic biomass substrate without manure addition have reflected crucial information about how to appropriately maintain the operational and particularly the environmental parameters in an agricultural biogas plant.

10/02830 Biofuel production potentials in Europe: sustainable use of cultivated land and pastures. Part I: land productivity potentials

Fischer, G. *et al. Biomass and Bioenergy*, 2010, 34, (2), 159–172.

IIASA's agro-ecological zones modelling framework has been extended for biofuel productivity assessments distinguishing five main groups of feedstocks covering a wide range of agronomic conditions and energy production pathways, namely: woody lignocellulosic plants, herbaceous lignocellulosic plants, oil crops, starch crops and sugar crops. A uniform Pan-European land resources database was compiled at the spatial resolution of 1 km^2. Suitability and productivity assessments were carried out by matching climate characteristics with plant requirements, calculating annual biomass increments or yields including consideration of soil and terrain characteristics of each grid-cell. Potential biomass productivity and associated energy yields were calculated for each grid-cell. Spatial distributions of suitabilities of biofuel feedstocks in Europe were generated for each individual feedstock as well as for the five biofuel feedstock groups. Estimated agronomical attainable yields, both in terms of biomass ($kg\,ha^{-1}$) as well as biofuel energy equivalent ($GJ\,ha^{-1}$), were mapped and tabulated by agriculture and pasture land cover classes as derived from the CORINE land cover database. Results have been further aggregated by administrative units at NUTS 2 level.

10/02831 Biofuel production potentials in Europe: sustainable use of cultivated land and pastures. Part II: land use scenarios

Fischer, G. *et al. Biomass and Bioenergy*, 2010, 34, (2), 173–187.

Europe's agricultural land (including Ukraine) comprise of 164 million hectares of cultivated land and 76 million hectares of permanent pasture. A 'food first' paradigm was applied in the estimations of land potentially available for the production of biofuel feedstocks, without putting at risk food supply or nature conservation. Three land conversion scenarios were formulated: (1) a base scenario, that reflects developments under current policy settings and respects current trends in nature conservation and organic farming practices, by assuming moderate overall yield increases; (2) an environment oriented scenario with higher emphasis on sustainable farming practices and maintenance of biodiversity; and (3) an energy oriented scenario considering more substantial land use conversions including the use of pasture land. By 2030 some 44–53 million hectares of cultivated land could be used for bioenergy feedstock production. The energy oriented scenario includes an extra 19 million hectares pasture land for feedstocks for second-generation biofuel production chains. Available land is foremost to be found in Eastern Europe, where substantial cultivated areas can be freed up through sustainable gains in yield in the food and feed sector. Agricultural residues of food and feed crops may provide an additional source for biofuel production. When assuming that up to 50% of crop residues can be used without risks for agricultural sustainability, it can be estimated that up to 246 Mt agricultural residues could be available for biofuel production, comparable to feedstock plantations of some 15–20 million hectares.

10/02832 Biogas purification from anaerobic digestion in a wastewater treatment plant for biofuel production

Osorio, F. and Torres, J. C. *Renewable Energy*, 2009, 34, (10), 2164–2171.

The main objective of this investigation consists in the biogas purification coming from the anaerobic digestion of sludges in a wastewater treatment plant, in order to be used later as biofuel for vehicles. This article consists of the optimization of the biogas desulphurization. In this case, this process was achieved in a chemical way. Besides the scrubbing towers, the pilot plant used included filters of activated carbon at the end of the line. The H_2S inflow concentrations were quite high. The effluent biogas from the scrubbing towers presented an H_2S concentration less than 1 ppm and zero or undetectable values were obtained for up to 58 analysed trace elements.

10/02833 Effects of 10% biofuel substitution on ground level ozone formation in Bangkok, Thailand

Milt, A. *et al. Atmospheric Environment*, 2009, 43, (37), 5962–5970.

The Thai Government's search for alternatives to imported petroleum led to the consideration of mandating 10% biofuel blends (biodiesel and gasohol) by 2012. Concerns over the effects of biofuel combustion on ground level ozone formation in relation to their conventional counterparts need addressing. Ozone formation in Bangkok is explored using a trajectory box model. The model is compared against O_3, NO, and NO_2 time concentration data from air monitoring stations operated by the Thai Pollution Control Department. Four high ozone days in 2006 were selected for modelling. Both the traditional trajectory approach and a citywide average approach were used. The model performs well with both approaches but slightly better with the citywide average. Highly uncertain and missing data are derived within realistic bounds using a genetic algorithm optimization. It was found that 10% biofuel substitution will lead to as much as a 16 ppb peak O_3 increase on these four days compared to a 48 ppb increase due to the predicted vehicle fleet size increase between 2006 and 2012. The approach also suggests that when detailed meteorological data is not available to run three-dimensional air-shed models, and if the air is stagnant or predominately remains over an urban area during the day, that a simple low cost trajectory analysis of O_3 formation may be applicable.

10/02834 Energy and exergy analysis of biomass gasification at different temperatures

Karamarkovic, R. and Karamarkovic, V. *Energy*, 2010, 35, (2), 537–549.

Biomass is usually gasified above the optimal temperature at the carbon-boundary point, due to the use of different types of gasifiers, gasifying media, clinkering/slagging of bed material, tar cracking, etc. This paper is focused on air gasification of biomass with different moisture at different gasification temperatures. A chemical equilibrium model is developed and analyses are carried out at pressures of 1 and 10 bar with the typical biomass feed represented by $CH_{1.4}O_{0.59}N_{0.0017}$. At the temperature range 900–1373 K, the increase of moisture in biomass leads to the decrease of efficiencies for the examined processes. The moisture content of biomass may be designated as 'optimal' only if the gasification temperature is equal to the carbon-boundary temperature for biomass with that specific moisture content. Compared with the efficiencies based on chemical energy and exergy, biomass feedstock drying with the product gas sensible heat is less beneficial for the efficiency based on total exergy. The gasification process at a given gasification temperature can be improved by the use of dry biomass and by the carbon-boundary temperature approaching the required temperature with the change of gasification pressure or with the addition of heat in the process.

10/02835 Environmental cost-effectiveness of bio diesel production in Greece: current policies and alternative scenarios

Iliopoulos, C. and Rozakis, S. *Energy Policy*, 2010, 38, (2), 1067–1078.
Following European Directive 2003/30/EC, the Greek Government adapted legislation that introduces and regulates the biodiesel market. The implemented quota scheme allocates the country's annual, predetermined, tax-exempt production of biodiesel to industries based on their ability to meet several criteria. A number of biodiesel supply chain stakeholders have criticized this policy for being efficiency-robbing and vague. This paper uses 2007 data from energy crop farms and three biodiesel-producing companies in order to assess these criticisms. The economic and environmental aspects of the currently adopted policy are studied and compared with three alternative scenarios. It is concluded that such criticisms have a merit and that policy makers need to reconsider their alternative options regarding the promotion of biodiesel in transport. Permission of sales directly to local consumers and promotion of forward integration by farmers are efficiency enhancing and environment-friendly means of promoting the use of biodiesel in transport.

10/02836 Extraction of sesame seed (*Sesamun indicum* L.) oil using compressed propane and supercritical carbon dioxide

Corso, M. P. *et al. The Journal of Supercritical Fluids*, 2010, 52, (1), 56–61.
This work is aimed to investigate the extraction of sesame seed (*Sesamun indicum* L.) oil using supercritical carbon dioxide and compressed propane as solvents. The extractions were performed in a laboratory scale unit in a temperature and pressure range of 313–333 K and 19–25 MPa for carbon dioxide and 303–333 K and 8–12 MPa for propane extractions, respectively. A 2^2 factorial experimental design with three replicates of the central point was adopted to organize the data collection for both solvents. The results indicated that solvent and density were important variables for the CO_2 extraction, while temperature is the most important variable for the extraction yield with propane. The extraction with propane was much faster than that with carbon dioxide due to the fact that propane is a better solvent for vegetable oils compared to carbon dioxide. On the other hand, characteristics of extracted oil, its oxidative stability determined by DSC and chemical profile of constituent fatty acids determined by gas chromatography, were similar to both solvents. The mathematical modelling of the extraction kinetics using a second order kinetic presented good results for the extraction with both solvents.

10/02837 Flash pyrolysis of grape residues into biofuel in a bubbling fluid bed

Xu, R. *et al. Journal of Analytical and Applied Pyrolysis*, 2009, 86, (1), 58–65.
The pyrolysis of two grape residues (grape skins and the mixture of grape skins and seeds) has been carried out in a pilot bubbling fluidized bed pyrolyser operating under a range of temperature from 300 to 600 °C and three vapour residence time (2.5, 5, and 20 s), with the aim of determining their pyrolysis behaviour including products yields and heat requirements. The composition of the product gases was determined, from which their heating value was calculated. The liquid bio-oil was recovered with cyclonic condensers and separated into two phases, an aqueous phase and an organic phase. The chemical composition of these liquid phases was characterized. In addition, the environmental parameters of the distilled fraction (85–115 °C) of the aqueous phase were tested, while the heating value of the organic phase was determined. Furthermore, the thermal sustainability of the pyrolysis process was estimated by considering the energy contribution of the product gases and of the liquid bio-oil in relation to the pyrolysis heat requirements. The optimum pyrolysis temperatures were identified in terms of maximizing the liquid yield, maximizing the energy from the product bio-oil, and maximizing the net energy from the product bio-oil after ensuring a self-sustainable process by utilizing the product gases and bio-oil as heat sources.

10/02838 Formation of NO_x precursors during wheat straw pyrolysis and gasification with O_2 and CO_2

Ren, Q. *et al. Fuel*, 2010, 89, (5), 1064–1069.
The release behaviour tests of NO_x precursors from wheat straw during pyrolysis in argon and gasification in 5%O_2/95%Ar and 5%CO_2/95%Ar were performed using a thermogravimetric analyser (TGA) coupled with a Fourier transform infrared (FTIR) spectrometer. The results show that heating rate and particle size have substantial effects on the selectivity of N-conversion due to the selectivity of cracking of cyclic amides and the secondary reaction influencing the formation of NH_3, HCN and HNCO. The atmosphere influences the N-selectivity to HCN, NH_3, NO and HNCO. The formation of HCN and NH_3 in 5%O_2/95%Ar is a result of competition among the opposing effects of O_2. The presence of O_2 promotes the yields of HCN and HNCO evidently, and HNCO seems to be a favourable product from biomass-N compared in Ar atmosphere although HCN yield is a little bigger than that of HNCO. The use of CO_2 reduces the formation of HCN, the yield of NH_3 keeps essentially constant compared in Ar, and the emission of HNCO is suppressed. NH_3 seems to be a favourable product from biomass-N in 5%CO_2/95%Ar.

10/02839 Gasification of aqueous biomass in supercritical water: a thermodynamic equilibrium analysis

Letellier, S. *et al. The Journal of Supercritical Fluids*, 2010, 51, (3), 353–361.
The aim of this work is to give insights into the gasification of aqueous biomass in supercritical water. More precisely, a mathematical model based on the thermodynamical equilibrium assumption is derived in this study. This model allows the computation of the solid, liquid and gas phases produced in a process composed of a gasification reactor and a separator. The composition of these three phases is computed in terms of fractions of CH_4, H_2, H_2O, CO, CO_2, H_2S, NH_3, C_6H_5OH, CH_3COOH, CH_3CHO, $C_{(s)}$ and minerals. In the reactor, this composition is computed according to the derivation of balance equations on atoms and to the derivation of equations translating chemical equilibrium between species. Because of the specific conditions prevailing in this device (above the critical point of pure water), the computation of the activity of chemical species in the reacting media is performed using Peng–Robinson equation of state. The modelling of the separator is performed using mass balances as well as equations translating physical equilibrium of species between liquid and gaseous phases. The numerical predictions of this mathematical model are compared to experimental results obtained in the case of gasification of methanol and glucose in supercritical water. The gasification of sewage sludge is also investigated in this study.

10/02840 Heat integrated heat pumping for biomass gasification processing

Pavlas, M. *et al. Applied Thermal Engineering*, 2010, 30, (1), 30–35.
The main part of this paper is an industrial case study. It deals with an application of a heat pump in energy systems for biomass gasification in a wood processing plant. Process integration methodology is applied to deal with complex design interactions as many streams requiring heating and cooling are involved in the energy recovery. A refrigeration cycle maintains low temperature in the scrubber where the production gas (or synthesis gas–syngas) is cooled and undesirable contaminants are removed before the syngas is introduced into the engine. In addition to electricity generation, a large amount of waste heat is available in the biomass gasification system studied in the paper, and its appropriate heat integration with utility systems within a plant allows the available heat to be efficiently utilized for the site. The conceptual understanding gained from the case study provides systematic design guidelines for further process development and industrial implementation in practice.

10/02841 Integrating bioenergy into computable general equilibrium models – a survey

Kretschmer, B. and Peterson, S. *Energy Economics*, 2010, 32, (3), 673–686.
In the past years biofuels have received increased attention since they were believed to contribute to rural development, energy security and to fight global warming. It became clear, though, that bioenergy cannot be evaluated independently of the rest of the economy and that national and international feedback effects are important. Computable general equilibrium (CGE) models have been widely employed in order to study the effects of international climate policies. The main characteristic of these models is their encompassing scope: global models cover the whole world economy disaggregated into regions and countries as well as diverse sectors of economic activity. Such a modelling framework unveils direct and indirect feedback effects of certain policies or shocks across sectors and countries. CGE models are thus well suited for the study of bioenergy/biofuel policies. One can currently find various approaches in the literature of incorporating bioenergy into a CGE framework. This paper gives an overview of existing approaches, critically assesses their respective power and discusses the advantages of CGE models compared to partial equilibrium models. Grouping different approaches into categories and highlighting their advantages and disadvantages is important for giving a structure to this rather recent and rapidly growing research area and to provide a guidepost for future work.

10/02842 Kinetic models based in biomass components for the combustion and pyrolysis of sewage sludge and its compost

Barneto, A. G. *et al. Journal of Analytical and Applied Pyrolysis*, 2009, 86, (1), 108–114.

In the present work, pyrolysis and combustion of the sewage sludge (fresh and composted) have been simulated using five fractions: low stability organic compounds, hemicellulose, cellulose, lignin-plastic, and inorganic compounds. Thermal behaviour and kinetic parameters (pre-exponential factor and apparent activation energy) of the main components of the sludge are similar to those reported for hemicellulose, cellulose, and lignin present in lignocellulosic biomass. Comparing non-isothermal thermogravimetric analysis data obtained from fresh and composted sewage sludge, it is possible to measure the efficiency of the composting process. Most of the biodegradable matter is volatized in a temperature range from 150 °C to 400 °C. Non-biodegradable organic matter volatilizes between 400 °C and 550 °C. In both, fresh and composted sludges, oxygen presence increases the mass loss rate at any temperature, but differences between pyrolysis and combustion are focused in two clearly defined ranges. At low temperature (200–350 °C), mass loss is related with a volatilization process. At higher temperature (350–550 °C), the mass loss was found to be due to slow char oxidation (oxidative pyrolysis).

10/02843 Management of biodiesel wastewater by the combined processes of chemical recovery and electrochemical treatment

Jaruwat, P. *et al. Energy Conversion and Management*, 2010, 51, (3), 531–537.

A two-stage management of raw biodiesel wastewater was carried out at a laboratory scale and at ambient temperature. In the first step, biodiesel was chemically recovered from the wastewater using sulfuric acid as a proton donor with subsequent natural phase separation. Biodiesel was recovered from the raw biodiesel wastewater, in this case at 6–7% (w/w). In the second stage, the aqueous phase discharged from the first stage was supplemented with sodium chloride to 0.061 M and subject to electro-oxidation using a Ti/RuO_2 electrode. The combined treatment completely removed chemical oxygen demand and oil and grease, and reduced biological oxygen demand levels by more than 95%. The rate of removal of all three pollutants fitted a pseudo-first-order rate kinetics with oil and grease removal being approximately 8–16- and 2–7-fold faster than biological oxygen demand and chemical oxygen demand removal, respectively.

10/02844 Modelling the costs of energy crops: a case study of US corn and Brazilian sugar cane

Méjean, A. and Hope, C. *Energy Policy*, 2010, 38, (1), 547–561.

This paper describes a simple probabilistic model of the costs of energy crops, drawing on the user's degree of belief about a series of parameters as an input. This forward-looking analysis quantifies the effects of production constraints and experience on the costs of corn and sugar cane, which can then be converted to bioethanol. Land is a limited and heterogeneous resource: the crop cost model builds on the marginal land suitability, which is assumed to decrease as more land is taken into production, driving down the marginal crop yield. Also, the maximum achievable yield is increased over time by technological change, while the yield gap between the actual yield and the maximum yield decreases through improved management practices. The results show large uncertainties in the future costs of producing corn and sugar cane, with a 90% confidence interval of 2.9–7.2$/GJ in 2030 for marginal corn costs, and 1.5–2.5$/GJ in 2030 for marginal sugar cane costs.

10/02845 Okra (*Hibiscus esculentus*) seed oil for biodiesel production

Anwar, F. *et al. Applied Energy*, 2010, 87, (3), 779–785.

Biodiesel was derived from okra (*Hibiscus esculentus*) seed oil by methanol-induced transesterification using an alkali catalyst. Transesterification of the tested okra seed oil under optimum conditions: 7:1 methanol to oil molar ratio, 1.00% (w/w) $NaOCH_3$ catalyst, temperature 65 °C and 600 rpm agitation intensity exhibited 96.8% of okra oil methyl esters (OOMEs) yield. The OOMEs/biodiesel produced was analysed by GC/MS, which showed that it mainly consisted of four fatty acids: linoleic (30.31%), palmitic (30.23%), oleic (29.09%) and stearic (4.93%). A small amount of 2-octyl cyclopropaneoctanoic acid with contribution 1.92% was also established. Fuel properties of OOMEs such as density, kinematic viscosity, cetane number, oxidative stability, lubricity, flash point, cold flow properties, sulfur contents and acid value were comparable with those of ASTM D 6751 and EN 14214, where applicable. It was concluded that okra seed oil is an acceptable feedstock for biodiesel production.

10/02846 Production and characterization of the biofuels obtained by thermal cracking and thermal catalytic cracking of vegetable oils

Prado, C. M. R. *et al. Journal of Analytical and Applied Pyrolysis*, 2009, 86, (2), 338–347.

The thermal cracking and the thermal catalytic cracking of soybean oil were evaluated for the production of biofuels as an alternative to fossil fuels. The catalyst proposed for the cracking reaction was bauxite, a high-acidity and low-cost catalyst. The chromatographic profile of the biofuels obtained by cracking showed hydrocarbon compounds such as alkanes, alkenes and aromatics, as well as some oxygenated compounds such as carboxylic acids, ketones and alcohols. The products generated by the thermal catalytic cracking process showed better results than the thermal cracking products because of the low quantity of acids present. The catalyst used was thus shown to act in the secondary cracking process, in which the fatty acids decompose and generate hydrocarbons.

10/02847 Production of vegetable oil-based biofuels – thermochemical behavior of fatty acid sodium salts during pyrolysis

Lappi, H. and Alén, L. *Journal of Analytical and Applied Pyrolysis*, 2009, 86, (2), 274–280.

To develop an advanced pyrolysis process for various biomass-derived feedstocks and improve product quality and yield, in-depth investigations into the reaction mechanisms are needed. This paper reports on pyrolysis experiments (Py-GC/MSD and FID) with model compounds including the sodium salts of stearic (C_{18}), oleic ($C_{18:1}$), and linoleic ($C_{18:2}$) acids principally obtained from alkaline hydrolysis of vegetable oils. Of the parameters studied – temperature (450–750 °C), time (20 s and 80 s), and the degree of unsaturation (i.e. saturated and mono- and dienoic C_{18}-hydrocarbon chains) – the latter had the most significant effect on the formation of volatile compounds detected in pyrolysates. The results indicated that in the case of sodium stearate, a homologous series of alkenes and alkanes was formed, whereas the pyrolysis of sodium oleate resulted mainly in aromatics, alkenes, and alkanes. In contrast, the most abundant liquefiable volatile products obtained from sodium linolate were aromatics and oxygen-containing compounds. In each case, an increase in temperature and time generally increased the quantity of products formed.

10/02848 Productive use of bioenergy for rural household in ecological fragile area, Panam County, Tibet in China: the case of the residential biogas model

Feng, T. *et al. Renewable and Sustainable Energy Reviews*, 2009, 13, (8), 2070–2078.

Bioenergy is the major domestic energy for rural households in developing countries due to its cheap or easy-getting characteristics. Productive use of bioenergy is an important strategy for rural households to improve not only their income, but also their health, living environment and so on. In Tibet of China, which is rich in cattle dung and firewood as the major energy sources for rural households, the efficiency of energy utilization is just about 10%. In order to improve energy utilization efficiency and the living conditions for rural residents, the Tibet Autonomous Region government introduced residential biogas model (RBM) to local households, which was a comprehensive utilization system of energy integrated with residential biogas digester, vegetable greenhouse and livestock shed. This paper aims to show the productive use of the bioenergy by the RBM, which could be depicted as the feasibility and the benefits on economic, eco-environmental and social aspects of biogas utilization, based on household questionnaires in Panam County. In RBM, biogas digester works as the biomass material supplement loop to transform originally biomass flow from single-direction to recycling-direction. The results indicate that the output of unit biogas digester could replace 1.44 t of firewood, 1.65 t of agricultural residues and 1.75 t of cattle dung, respectively. The net incremental benefit of RBM could reach 5550.72 Yuan in 15 years. The reduced amount of CO_2 emission when substituted by biogas in other agricultural areas and the areas of semi-agricultural and semi-husbandry in Tibet could be (76.66–79.89) $\times 10^4$ t/year and the capability for nitrogen storage could achieve (0.39–0.99) $\times 10^4$ t/year. The amount of cattle dung replaced by biogas could reach 78.29×10^4 t/year; this means that the saved cattle dung, 3.51 t/hm^2, could be reallocated back to cultivated land to improve the soil fertility and to keep the balance of nutrient elements in cultivated land. Biogas utilization reduces the labour opportunity costs of women compared to use of traditional bioenergy sources. It could be concluded that the productive use of bioenergy through RBM in this area has its capability to release the current pressures on biomass sources by adjusting patterns of rural energy consumption, and to improve the conditions of health, environment, economy and energy conservation.

10/02849 Small-scale production of straight vegetable oil from rapeseed and its use as biofuel in the Spanish territory

Grau, B. *et al. Energy Policy*, 2010, 38, (1), 189–196.

Straight vegetable oil (SVO) can be used directly in diesel engines with minor modifications. The proposal here is a small-scale SVO production system for self-supply in agricultural machinery. In this paper a model to provide SVO to local farmers in a specific area in Catalonia (Spain) is presented. The authors also present a discussion about the regulations to be changed in order to make possible the incorporation of SVO as engine fuel in diesel vehicles and a comparative analysis between the emissions of tractors fed with SVO and petrodiesel. Moreover, a quantitative economic analysis of modifying diesel engines and long-term operability costs are shown and a first-run economic analysis comparing the actual crop rotation with the proposed one and some alternatives is studied.

10/02850 Spray combustion properties of fast pyrolysis bio-oil produced from rice husk

Zheng, J.-L. and Kong, Y.-P. *Energy Conversion and Management*, 2010, 51, (1), 182–188.

The research presented here is focused primarily on spray combustion of pure fast pyrolysis bio-oil from rice husk. A combustion systems is developed to attain a possibility of firing of the bio-oil in a routine way. The start-up and shut down combustion procedures is established. The bio-oil is properly pretreated and spray combustion properties of pure fast pyrolysis bio-oil are studied. After 40 min combustion become steady and the temperature in the centre of the combustion chamber is above 1400 °C. The CO concentration decreases with ER, and below a certain ER, the CO level exponentially increases. The measured NO_x concentrations slightly increase at higher ER. Low values of SO_x emissions are measured, and as expected these values are very low (< 30 ppm). The O_2 concentration increases with ER. Bio-oil has the potential to replace diesel and gas for on-site power generation and heating, to be a fuel source for large-scale combustion systems such as furnaces, boilers and gas turbines.

Geothermal energy

10/02851 A review of methods to evaluate borehole thermal resistances in geothermal heat-pump systems

Lamarche, L. *et al. Geothermics*, 2010, 39, (2), 187–200.

In the design of a ground-source heat pump (GSHP) system, the heat transfer from the fluid to the ground is influenced by the thermal borehole resistance between the fluid and the borehole surface and also by the interference resistance between the two (or four) pipes inside the borehole. Several authors have proposed empirical and theoretical relations to evaluate these resistances as well as methods to evaluate them experimentally. The paper compares the different approaches and proposes good practice to evaluate the resistances. The impact of the different approaches on the design of heat exchanger is also examined. Two-dimensional and fully three-dimensional numerical simulations are used to evaluate the different methods. A new method is also proposed to evaluate the borehole resistances from in situ tests.

10/02852 A snapshot of geothermal energy potential and utilization in Turkey

Erdogdu, E. *Renewable and Sustainable Energy Reviews*, 2009, 13, (9), 2535–2543.

Turkey is one of the countries with significant potential in geothermal energy. It is estimated that if Turkey utilizes all of her geothermal potential, she can meet 14% of her total energy need (heat and electricity) from geothermal sources. Therefore, today geothermal energy is an attractive option in Turkey to replace fossil fuels. The increase in negative effects of fossil fuels on the environment has forced many countries, including Turkey, to use renewable energy sources. Also, Turkey is an energy importing country; more than two-thirds of her energy requirement is supplied by imports. In this context, geothermal energy appears to be one of the most efficient and effective solutions for sustainable energy development and environmental pollution prevention in Turkey. Since geothermal energy will be used more and more in the future, its current potential, usage, and assessment in Turkey is the focus of the present study. The paper not only presents a review of the potential and utilization of the geothermal energy in Turkey but also provides some guidelines for policy makers.

10/02853 Barriers and enablers to geothermal district heating system development in the United States

Thorsteinsson, H. H. and Tester, J. W. *Energy Policy*, 2010, 38, (2), 803–813.

According to the US Energy Information Administration, space and hot water heating represented about 20% of total US energy demand in 2006. Given that most of this demand is met by burning natural gas, propane, and fuel oil, an enormous opportunity exists for directly utilizing indigenous geothermal energy as a cleaner, nearly emissions-free renewable alternative. Although the USA is rich in geothermal energy resources, they have been frequently undervalued in America's portfolio of options as a means of offsetting fossil fuel emissions while providing a local, reliable energy source for communities. Currently, there are only 21 operating GDHS in the USA with a capacity of about 100 MW thermal. Interviews with current US district heating operators were used to collect data on and analyse the development of these systems. This article presents the current structure of the US regulatory and market environment for GDHS along with a comparative study of district heating in Iceland where geothermal energy is extensively utilized. It goes on to review the barriers and enablers to utilizing geothermal district heating systems (GDHS) in the USA for space and hot water heating and provides policy recommendations on how to advance this energy sector in the USA.

10/02854 Current status of ground-source heat pumps in China

Yang, W. *et al. Energy Policy*, 2010, 38, (1), 323–332.

As a renewable energy technology, the ground-source heat pump (GSHP) technologies have increasingly attracted world-wide attention due to their advantages of energy efficiency and environmental friendliness. This paper presents Chinese research and application on GSHP followed by descriptions of patents. The policies related to GSHP are also introduced and analysed. With the support of Chinese government, several new heat transfer models and two new GSHP systems (named pumping and recharging well (PRW) and integrated soil cold storage and ground-source heat pump (ISCS & GSHP) system) have been developed by Chinese researchers. The applications of GSHP systems have been growing rapidly since the beginning of the twenty-first century with financial incentives and supportive government policies. However, there are still several challenges for the application of GSHP systems in large scale. This paper raises relevant suggestions for overcoming the existing and potential obstacles. In addition, the developing and applying prospects of GSHP systems in China are also discussed.

10/02855 Evaluation of heat exchange rate of GHE in geothermal heat pump systems

Liu, J. *et al. Renewable Energy*, 2009, 34, (12), 2898–2904.

Total thermal resistance of ground heat exchanger (GHE) is comprised of that of the soil and inside the borehole. The thermal resistance of soil can be calculated using the linear source theory and cylindrical source theory, while that inside the borehole is more complicated due to the integrated resistance of fluid convection, and the conduction through pipe and grout. Present study evaluates heat exchange rate per depth of GHE by calculating the total thermal resistance, and compares different methods to analyse their similarities and differences for engineering applications. The effects of seven separate factors, running time, shank spacing, depth of borehole, velocity in the pipe, thermal conductivity of grout, inlet temperature and soil type, on the thermal resistance and heat exchange rate are analysed. Experimental data from several real geothermal heat pump (GHP) applications in Shanghai are used to validate the present calculations. The observations from this study are to provide some guidelines for the design of GHE in GHP systems.

10/02856 Field-scale evaluation of the design of borehole heat exchangers for the use of shallow geothermal energy

Kim, S.-K. *et al. Energy*, 2010, 35, (2), 491–500.

A numerical model for the simulation of temperature changes in a borehole heat exchanger (BHE) with fluid circulating through U-tubes is developed. The model can calculate the thermal power transferred from heat pumps to BHEs while considering the nonlinear relationship between temperature of the circulating fluid and the thermal power. The use of the developed model enables the design of a geothermal heat pump (GHP) system with the view of pursuing efficiency and financial benefit. The developed model is validated by comparing two measurement datasets with their respective simulation results. The numerical evaluation of a real GHP system with 28 BHEs and 79 heat pumps involved consideration of a base case and modified cases. In all cases, the temperatures of the circulating fluid at the BHE inlet and outlet, heat pump efficiency, and the heating power and electric power of heat pumps were obtained. The estimated cost of electricity in the year 2030 is 0.146 US$/kW. The most cost-effective system in this case is for there to be 4, 6, and 6 BHEs on the first, second, and third floors, respectively.

10/02857 First in situ determination of the ground thermal conductivity for boreholeheat exchanger applications in Saudi Arabia

Sharqawy, M. H. *et al. Renewable Energy*, 2009, 34, (10), 2218–2223.
The paper deals with the *in situ* experimental determination of the thermal properties of the underground soil for use in the design of borehole heat exchangers (BHE). The approach is based on recording the unsteady thermal response of a BHE that has been installed for the first time in Saudi Arabia. In this approach, the temperature of the circulating fluid has been recorded at the inlet and outlet sections of the BHE with time following the start of its operation. Severe fluctuations in these temperatures occur at small times (up to 8 h) due to the transient effects inside the borehole and must be excluded. A method has been developed for estimating the time period characterized by these severe fluctuations. The recorded thermal responses together with the line source theory are used to determine the thermal conductivity, thermal diffusivity and the steady-state equivalent thermal resistance of the underground soil.

10/02858 Geothermal resources in Algeria

Saibi, H. *Renewable and Sustainable Energy Reviews*, 2009, 13, (9), 2544–2552.
The geothermal resources in Algeria are of low-enthalpy type. Most of these geothermal resources are located in the northeastern of the country. There are more than 240 thermal springs in Algeria. Three geothermal zones have been delineated according to some geological and thermal considerations: (1) The Tlemcenian dolomites in the northwestern part of Algeria, (2) carbonate formations in the north-eastern part of Algeria and (3) the sandstone Albian reservoir in the Sahara (south of Algeria). The northeastern part of Algeria is geothermally very interesting. Two conceptual geothermal models are presented, concerning the northern and southern part of Algeria. Application of gas geothermometry to northeastern Algerian gases suggests that the reservoir temperature is around 198 °C. The quartz geothermometer when applied to thermal springs gave reservoir temperature estimates of about 120 °C. The thermal waters are currently used in balneology and in a few experimental direct uses (greenhouses and space heating). The total heat discharge from the main springs and existing wells is approximately 642 MW. The total installed capacity from producing wells and thermal springs is around 900 MW.

10/02859 Soil temperature distribution around a U-tube heat exchanger in a multi-function ground source heat pump system

Li, S. *et al. Applied Thermal Engineering*, 2009, 29, (17–18), 3679–3686.
The imbalance of heat extracted from the earth by the underground heat exchangers in winter and ejected into it in summer is expected to affect the long-term performance of conventional ground source heat pump (GSHP) in territories with a cold winter and a warm summer such as the middle and downstream areas of the Yangtze River in China. This paper presents a new multi-function ground source heat pump (MFGSHP) system which supplies hot water as well as space cooling/heating to mitigate the soil imbalance of the extracted and ejected heat by a ground source heat pump system. The heat transfer characteristic is studied and the soil temperature around the underground heat exchangers are simulated under a typical climatic condition of the Yangtze River. A three-dimensional model was constructed with the commercial computational fluid dynamics software FLUENT based on the inner heat source theory. Temperature distribution and variation trend of a tube cluster of the underground heat exchanger are simulated for the long term performance. The results show that the soil temperature around the underground tube keeps increasing due to the surplus heat ejected into the earth in summer, which deteriorates the system performance and may lead to the eventual system deterioration. The simulation shows that MFGSHP can effectively alleviate the temperature rise by balancing the heat ejected to/extracted from underground by the conventional ground source heat pump system. The new system also improves the energy efficiency.

10/02860 Temperature distributions in boreholes of a vertical ground-coupled heat pump system

Esen, H. *et al. Renewable Energy*, 2009, 34, (12), 2672–2679.
The objective of this study is to show the temperature distribution development in the borehole of the ground-coupled heat pump systems (GCHPs) with time. The time interval for the study is 48 h. The vertical GCHP system using R-22 as refrigerant has a three single U-tube ground heat exchanger (GHE) made of polyethylene pipe with a 40 mm outside diameter. The GHE was placed in a vertical borehole (VB) with 30 (VB1), 60 (VB2) and 90 (VB3) m depths and 150 mm diameters. The experimental results were obtained in cooling and heating seasons of 2006–2007. A two-dimensional finite element model (FEM) was developed to simulate temperature distribution development in the soil surrounding the GHEs of GCHPs operating in the cooling and the heating modes. The finite element modelling of the GCHP system was performed using the ANSYS code. The FEM incorporated pipes, the grout and the surrounding formation. From the cases studied, this approach appears to be the most promising for estimation the temperature distribution response of GHEs to thermal loading.

Solar energy

10/02861 A comparative assessment of thin-film photovoltaic production processes using the ELECTRE III method

Cavallaro, F. *Energy Policy*, 2010, 38, (1), 463–474.
The use of renewable energy sources for the production of electric power brings huge benefits both in terms of environmental protection as well as savings in non-renewable resources. Photovoltaic stands out from other renewable energy sources for its simplicity and the modularity of its energy conversion system. To date, the most highly developed technology for the construction of solar cells is one based on mono and polycrystalline silicon. An alternative production line is currently under development to produce, thin-film modules. There are currently a variety of processes and materials available to make thin-film cells but their relative costs and performance differ. Therefore, it would be useful to make a comparative evaluation of the different processes using a multiple criteria method. This paper proposes an application of an outranking methodology to assess a selection of production processes of thin-film solar technology. As this work demonstrates, multi-criteria analysis can provide a technical-scientific decision making support tool that is able to justify its choices clearly and consistently in the renewable energy sector.

10/02862 A methodology of computation, design and optimization of solar Stirling power plant using hydrogen/oxygen fuel cells

Petrescu, S. *et al. Energy*, 2010, 35, (2), 729–739.
The objective of this paper is to develop a methodology to determine how many houses could be fuelled from the solar energy captured by a number of solar Stirling modules (with a fixed dish area per module) and also to determine the minimum necessary area of the fuel cell to ensure the amount of power needed to meet daily energy use requirements. The detailed method includes the effect of the fuel cell efficiency function on the power consumption of the user. Experimental data from the laboratory are used to determine the fuel cell efficiency as a function of the electric current density for a specific power demand. As an illustrative example, the analysis is applied to a residential area having a specific electrical demand. Using the developed method, the number of houses that could be fuelled directly by the stored hydrogen is determined, and also the minim fuel cell area required.

10/02863 A review of principle and sun-tracking methods for maximizing solar systems output

Mousazadeh, H. *et al. Renewable and Sustainable Energy Reviews*, 2009, 13, (8), 1800–1818.
Finding energy sources to satisfy the world's growing demand is one of society's foremost challenges for the next half-century. The challenge in converting sunlight to electricity via photovoltaic solar cells is dramatically reducing $/watt of delivered solar electricity. In this context the sun trackers are such devices for efficiency improvement. The diurnal and seasonal movement of earth affects the radiation intensity on the solar systems. Sun-trackers move the solar systems to compensate for these motions, keeping the best orientation relative to the sun. Although using sun-tracker is not essential, its use can boost the collected energy 10–100% in different periods of time and geographical conditions. However, it is not recommended to use tracking system for small solar panels because of high energy losses in the driving systems. It is found that the power consumption by tracking device is 2–3% of the increased energy. In this paper different types of sun-tracking systems are reviewed and their cons and pros are discussed. The most efficient and popular sun-tracking device was found to be in the form of polar-axis and azimuth/elevation types.

10/02864 A review of the mathematical models for predicting solar air heaters systems

Tchinda, R. *Renewable and Sustainable Energy Reviews*, 2009, 13, (8), 1734–1759.
A mathematical model of the closed solar air heaters is used in particular, to assist in interpreting the observed phenomena in the solar air heaters, to design the system, to predict the trends, and to assist in optimization. In this paper, various mathematical models, mainly analysing the heat transfer process of solar air heaters, are reviewed

and classified based on the model, the number of the cover, the shape of the absorber and the presence or not of the packing bed. Although the models have evolved to a point where several features of the process can be predicted, more effort is required before the models can be applied to define actual operating conditions as well as to further investigate new closed solar air heaters. It is shown that the major governing equations in the models are based on the first law of thermodynamics.

10/02865 Complete modeling and software implementation of a virtual solar hydrogen hybrid system

Pedrazzi, S. *et al. Energy Conversion and Management*, 2010, 51, (1), 122–129.

A complete mathematical model and software implementation of a solar hydrogen hybrid system has been developed and applied to real data. The mathematical model has been derived from sub-models taken from literature with appropriate modifications and improvements. The model has been implemented as a stand-alone virtual energy system in a model-based, multi-domain software environment. A test run has then been performed on typical residential user data-sets over a year-long period. Results show that the virtual hybrid system can bring about complete grid independence; in particular, hydrogen production balance is positive (+1.25 kg) after a year's operation with a system efficiency of 7%.

10/02866 Conventional versus storage domestic solar hot water systems: a comparative performance study

Khalifa, A. J. N. and Abdul Jabbar, R. A. *Energy Conversion and Management*, 2010, 51, (2), 265–270.

This paper presents an experimental comparative performance study between a storage solar domestic hot water system and a conventional one. The storage system differs from the conventional one by integrating the collector and storage tank into one piece of equipment. The investigated storage collector consists of six 80-mm-outside diameter copper tubes connected in series to act as an absorber and a storage tank. Tests under different flow patterns are conducted to simulate different patterns of hot water consumption. The overall heat loss coefficient, useful heat gain, instantaneous efficiency, efficiency factor, heat removal factor and the temperature distribution along the pipe are determined using modified equations derived for the storage collector from the basic derivation of Hottel–Bliss–Whillier. A comparison between the experimental and theoretical results for the storage collector showed good agreements and that between the two systems showed the superiority of the storage system.

10/02867 Employing exergy-optimized pin fins in the design of an absorber in a solar air heater

Nwosu, N. P. *Energy*, 2010, 35, (2), 571–575.

Fins serve as heat transfer augmentation features in solar air heaters however they increase pressure drop in flow channels. Pin fins are relatively good heat transfer augmentation features with superior aerodynamic performance and as a result find application in some solar air heaters. The exergy optimization method is employed in sizing the pin fin. Results indicate that high efficiency of the optimized fin improves the heat absorption and dissipation potential of a solar air heater. With optimum fin efficiency and superior absorptive coating quality, useful energy losses can be minimized. Some important observations pertinent in design are made.

10/02868 Experimental study on a new solar boiling water system with holistic track solar funnel concentrator

Xue, X. *et al. Energy*, 2010, 35, (2), 692–697.

A new solar boiling water system with conventional vacuum-tube solar collector as primary heater and the holistic solar funnel concentrator as secondary heater had been designed. In this paper, the system was measured out door and its performance was analysed. The configuration and operation principle of the system are described. Variations of the boiled water yield, the temperature of the stove and the solar irradiance with local time have been measured. Main factors affecting the system performance have been analysed. The experimental results indicate that the system produced large amount of boiled water. And the performance of the system has been found closely related to the solar radiance. When the solar radiance is above 600 W/m^2, the boiled water yield rate of the system has reached 20 kg/h and its total energy efficiency has exceeded 40%.

10/02869 'From graft to bottle' – analysis of energy use in viticulture and wine production and the potential for solar renewable technologies

Smyth, M. and Russell, J. *Renewable and Sustainable Energy Reviews*, 2009, 13, (8), 1985–1993.

The practice of viticulture and winemaking is highly dependent upon the weather and climate. Any future changes in the seasons, their duration, local maximum, minimum and mean temperatures, frost occurrence and heat accumulation could have a major impact on the winegrowing areas of the world. Given that the winegrowing industry has substantial energy requirements and is directly influenced by any changes in climate, the industry should be at the forefront in promoting the case of energy efficiency and the adoption of renewable technologies. Solar renewables in the form of solar thermal and photovoltaics (PVs) offer a complimentary solution to many winegrowing processes. This paper examines the limited number of world wineries that have adopted solar renewables and presents a viable case for their wide scale integration into the industry. The paper presents a range of viticultural and winemaking processes where solar energy can be directly or indirectly applied and suggests the potential for solar energy in making substantial savings in both energy use and greenhouse gas emissions. In 2005, almost 8 million hectares were under vines producing 40.2 million tonnes of grapes for crushing. The total global energy use within the winemaking industry is estimated at over 105 PJ emitting nearly 16 million tonnes of CO_2. If ancillary industries, such as bottle making and transportation are included, the total carbon footprint of the industry is estimated at over 76 million tonnes of CO_2. This paper calculates that if the commercial winemaking establishments in the 'developed' wine producing regions of the world integrated a 'small' solar installation into their wineries, the potential savings are 18.3% or 19.24 PJ of the energy used in the global winemaking industry.

10/02870 Genetic algorithms optimized fuzzy logic control for the maximum power point tracking in photovoltaic system

Larbes, C. *et al. Renewable Energy*, 2009, 34, (10), 2093–2100.

This paper presents an intelligent control method for the maximum power point tracking (MPPT) of a photovoltaic system under variable temperature and irradiance conditions. First, for the purpose of comparison and because of its proven and good performances, the perturbation and observation (P&O) technique is briefly introduced. A fuzzy logic controller based MPPT (FLC) is then proposed which has shown better performances compared to the P&O MPPT based approach. The proposed FLC has been also improved using genetic algorithms (GA) for optimization. Different development stages are presented and the optimized fuzzy logic MPPT controller (OFLC) is then simulated and evaluated, which has shown better performances.

10/02871 Heat loss study of trapezoidal cavity absorbers for linear solar concentrating collector

Singh, P. L. *et al. Energy Conversion and Management*, 2010, 51, (2), 329–337.

There should be minimum heat loss from the absorber to achieve better efficiency of the solar collector. Overall heat loss coefficients of the trapezoidal cavity absorber with rectangular and round pipe were studied in the laboratory. Two identical rectangular pipe absorbers (section size: 100×23 mm, thickness: 2.5 mm and length 2170 mm) and two round pipe absorbers (a set of six mild steel round tubes of 16 mm diameter and 2.5 mm thickness brazed together in single layer making 100 mm width) were fabricated. A rectangular and a round pipe were painted with ordinary mat black paint (emissivity at 100 °C = 0.91) and one pipe of each type was coated with black nickel selective surface (emissivity at 100 °C = 0.17). Overall heat loss coefficient of the absorber was studied by circulating hot oil through it at different temperatures. The heat loss coefficient was increased with the absorber temperature. The heat loss coefficients for ordinary black coated and selective surface coated round pipe absorbers were varied from 3.5 to 7.5 W/m^2/°C and 2.7–5.8 W/m^2/°C respectively. The rectangular pipe section has marginally higher heat loss coefficients as compared to round pipe absorber. Selective surface coating on the absorbers reduced heat loss coefficient significantly by 20–30% as compared to ordinary black coating. The double glass cover also reduced heat loss coefficient by 10–15% as compared to single glass cover. The overall heat loss coefficients were also estimated analytically by parallel plate correlation and cavity correlations. The trend of variation of estimated heat loss coefficients by both methods was similar to experimental values. However, estimated values by cavity correlation were closure and uniformly distributed at all temperature range.

10/02872 Modeling, control, and simulation of dual rotor wind turbine generator system

No, T. S. *et al. Renewable Energy*, 2009, 34, (10), 2124–2132.

A new wind turbine generator system (WTGS) is introduced, and its mathematical model, blade pitch control scheme, and nonlinear simulation software for the performance prediction are presented. The notable feature of WTGS is that it consists of two rotor systems positioned horizontally at upwind and downwind locations, and a generator installed vertically inside the tower. In this paper, this new WTGS is treated as a constrained multi-body system, and the equations of motion are obtained by using the multi-body dynamics approach. Aerodynamic forces and torques generated from each of rotor blades are calculated using the blade element theory. Various pitch control schemes depending on the wind speed and the main rotor's rotational speed are implemented. A relatively simple model for the load torque is obtained by using the test data of the doubly fed induction generator adopted in the new WTGS. Finally, FORTRAN and Matlab/Simulink-based hybrid simulation software is developed and used to predict and analyse the performance of the WTGS.

10/02873 Numerical simulation of a Linear Fresnel reflector concentrator used as direct generator in a solar-GAX cycle

Velázquez, N. *et al. Energy Conversion and Management*, 2010, 51, (3), 434–445.

In this work a methodological analysis to design and evaluate the technical feasibility of use a linear Fresnel reflector concentrator (LFRC) as generator in an advanced absorption refrigeration system (solar-GAX cycle) has been carried out. For this purpose, a detailed one-dimensional numerical simulation of the thermal and fluid-dynamic behaviour of a LFRC that solves, in a segregated manner, four subroutines: (a) fluid flow inside the receptor tube, (b) heat transfer in the receptor tube wall, (c) heat transfer in cover tube wall, and (d) solar thermal analysis in the solar concentrator has been developed. The LFRC numerical model has been validated with experimental data obtained from the technical literature; after that, a parametric study for different configurations of design has been carried out in order to obtain the highest solar concentration with the lowest thermal losses, keeping in mind both specific weather conditions and construction restrictions. The numerical result obtained demonstrates that using a LFRC as a direct generator in a solar-GAX cycle satisfy not only the quantity and quality of the energy demanded by the advanced cooling system, it also allows to obtain higher global efficiencies of the system due to it can be operated in conditions where the maximum performance of the solar-GAX cycle is obtained without affecting in any significant way the solar collector efficiency.

10/02874 Performance analysis of photovoltaic systems: a review

Joshi, A. S. *et al. Renewable and Sustainable Energy Reviews*, 2009, 13, (8), 1884–1897.

In this paper, a thorough review of photovoltaic and photovoltaic thermal systems is done on the basis of its performance based on electrical as well as thermal output. Photovoltaic systems are classified according to their use, i.e. electricity production and thermal applications along with the electricity production. The application of various photovoltaic systems is also discussed in detail. The performance analysis including all aspects, e.g. electrical, thermal, energy, and exergy efficiency are also discussed. A case study for PV and PV/T system based on exergetic analysis is presented.

10/02875 Photovoltaic field emulation including dynamic and partial shadow conditions

Di Piazza, M. C. and Vitale, G. *Applied Energy*, 2010, 87, (3), 814–823.

In this paper the development of a new laboratory prototype for the emulation of a photovoltaic (PV) field is presented. The proposed system is based on a DC/DC step-down converter topology and allows to obtain the solar array *I–V* curves, taking into account the environmental changes in solar irradiance and cell temperature. The DC/DC converter control strategy is deduced by using a comprehensive mathematical model of the PV field whose parameters are obtained from the knowledge of: (a) maximum power point data, measured when the PV plant power converter is running, (b) open circuit voltage and short-circuit current, measured off-line. This approach allows the most accurate representation of the PV source. Computer simulations and experimental results demonstrate that the proposed circuit acts as a highly accurate and efficient laboratory simulator of the photovoltaic array electrical characteristics both in steady state and transient conditions. Partial shading and fluctuating conditions can be reproduced too. Moreover the dynamic behaviour of the proposed laboratory emulator is suitable to its effective connection to power electronic interface to the utility or to load through a DC/DC boost converter.

10/02876 Reference module selection criteria for accurate testing of photovoltaic (PV) panels

Roy, J. N. *et al. Solar Energy*, 2010, 84, (1), 32–36.

It is shown that for accurate testing of PV panels the correct selection of reference modules is important. A detailed description of the test methodology is given. Three different types of reference modules, having different I_{SC} (short circuit current) and power (in Wp) have been used for this study. These reference modules have been calibrated from NREL. It has been found that for accurate testing, both I_{SC} and power of the reference module must be either similar or exceed to that of modules under test. In case corresponding values of the test modules are less than a particular limit, the measurements may not be accurate. The experimental results obtained have been modelled by using simple equivalent circuit model and associated *I–V* equations.

10/02877 Scaling up concentrating solar thermal technology in China

Li, J. *Renewable and Sustainable Energy Reviews*, 2009, 13, (8), 2051–2060.

More than 1300 GW new generating capacity will be added in China's power sector over the period 2005–2030 under the BAU scenario in, even higher than the total installed capacity in the United States to date. China's industrial and service sectors are expected to maintain rapid development rate over the next decades, driving up the demand for electric power and heat. However, China's power and industrial process heat generation are heavily relying upon coal-fired thermal power plants resulting in tremendous rise in greenhouse gas emissions. Clean technology such as concentrating solar thermal (CST) needs to play a more important role in power and heat generation in China to accelerate the decarbonization in the power sector and commercial and industrial process heat generation cost-effectively. This paper attempts to explore the opportunity and challenge of development and deployment of CST in China from both technical and socioeconomic analysis perspectives. It is argued that rapid deployment of CST in China will contribute to enabling sustainable energy supply and environmental securities, as well as improved economic performance in new technology innovation in Asia Pacific area over the next decades. Supportive policy framework should be set up to encourage scaling up CST industry. The success of deployment of CST technology will also allow Chinese power and heat generators to strengthen their competitiveness in the context of intensified global constraint of carbon emissions. Institutional innovation and policy instruments for scaling up this technology and the enabling conditions of successful implementation are also investigated.

10/02878 Situation and outlook of solar energy utilization in Tibet, China

Wang, Q. and Qiu, H.-N. *Renewable and Sustainable Energy Reviews*, 2009, 13, (8), 2181–2186.

The near-exponential rise in tourist numbers and accelerating economic growth have challenged Tibetan energy supply and threaten its peculiar environment and valuable ecosystem. Exploitation of pollution-free solar power may help this demand for energy. This is a review of solar power development in Tibet: a region that has a near inexhaustible source of solar energy due to its average annual radiation intensity of 6000–8000 MJ/m^2, ranking it first in China and second after the Sahara worldwide. Currently, Tibet has 400 photovoltaic power stations with a total capacity of nearly 9 MW. In addition, 260,000 solar energy stoves, passive solar house heating covering 3 million square metres, and 400,000 m^2 of passive solar water heaters are currently in use in Tibet. Although Tibet places first in applying solar energy in China, solar energy faces big challenges from hydroelectric power and the absence of local know-how. The new power generation capacity in Tibet's '11th Five-Year (2006–2010)' Plan focuses primarily on hydropower, PV power stations being relegated to a secondary role as supplementary to hydropower. Here it is argued that this emphasis is incorrect and that solar energy should take first place in Tibet's energy development, as it is crucial in striving for a balance between economic development, booming tourism, and environmental protection.

10/02879 Solar water heaters in China: a new day dawning

Han, J. *et al. Energy Policy*, 2010, 38, (1), 383–391.

Solar thermal utilization, especially the application of solar water heater technology, has developed rapidly in China in recent decades. Manufacturing and marketing developments have been especially strong in provinces such as Zhejiang, Shandong and Jiangsu. This paper takes Zhejiang, a relatively affluent province, as a case study area to assess the performance of solar water heater utilization in China. The study will focus on institutional setting, economic and technological performance, energy performance, and environmental and social impact. Results show that China has greatly increased solar water heater utilization, which has brought China great economic, environmental and social benefits. However, China is confronted with malfeasant market competition, technical flaws in solar water heater products and social conflict concerning solar water heater installation. For further development of the solar water heater, China should clarify the compulsory installation policy and include solar water heaters into the current 'Home Appliances Going to the Countryside' project; most of the widely used vacuum tube products should be replaced by flat plate products, and the technology improvement should focus on anti-freezing and water saving; the resources of solar water heater market should be consolidated and most of the original equipment manufacturers should evolve to original design manufacturer and original brand manufacturer enterprises.

10/02880 Stand-alone photovoltaic (PV) integrated with earth to air heat exchanger (EAHE) for space heating/cooling of adobe house in New Delhi (India)

Chel, A. and Tiwari, G. N. *Energy Conversion and Management*, 2010, 51, (3), 393–409.

This paper deals with an experimental outdoor annual performance evaluation of 2.32 kW_P photovoltaic (PV) power system located at solar energy park in New Delhi composite climatic conditions. This PV system operates the daily electrical load nearly 10 kW h/day which comprises of various applications such as electric air blower of an earth to air heat exchanger (EAHE) used for heating/cooling of adobe house, ceiling fan, fluorescent tube-light, computer, submersible water pump, etc. The outdoor efficiencies, power generated and lost in PV system components were determined using hourly experimental measured data for 1 year on typical clear day in each month. These realistic data are useful for design engineers for outdoor assessment of PV system components. The energy conservation, mitigation of CO_2 emission and carbon credit potential of the existing PV integrated EAHE system is presented in this paper. Also, the energy payback time (EPBT) and unit cost of electricity were determined for both stand-alone PV (SAPV) and building roof integrated PV (BIPV) systems.

10/02881 Turbidity study of solar ponds utilizing seawater as salt source

Li, N. *et al. Solar Energy*, 2010, 84, (2), 289–295.

A series of experiments were conducted to study the turbidity reduction in solar ponds utilizing seawater as salt source. The experiment on the turbidity reduction efficiency with chemicals indicates that alum ($KAl(SO_4)_2{\cdot}12H_2O$) has a better turbidity control property because of its strongly flocculating and also well depressing the growing of algae and bacteria in the seawater. In comparison with bittern and seawater, the experiment shows that the residual brine after desalination can keep limpidity for a long time even without any chemical in it. Experiments were also conducted on the diffusion of turbidity and salinity, which show that the turbidity did not diffuse upwards in the solution. In the experiment on subsidence of soil in the bittern and saline with the same salinity, it was found that soil subsided quite quickly in the pure saline water, but very slowly in the bittern. This paper also proposes an economical method to protect the solar pond from the damage of rain. Finally, thermal performance of a solar pond was simulated in the conditions of different turbidities using a thermal diffusion model.

10/02882 Viability analysis of PV power plants in Egypt

EL-Shimy, M. *Renewable Energy*, 2009, 34, (10), 2187–2196.

This paper investigates, from techno-economical and environmental points of view, the feasible sites in Egypt to build a 10 MW PV-grid connected power plant. Available PV-modules are assessed and a module is selected for this study. The long-term meteorological parameters for each of the 29 considered sites in Egypt from NASA renewable energy resource website (Surface meteorology and Solar Energy) are collected and analysed in order to study the behaviours of solar radiations, sunshine duration, air temperature, and humidity over Egypt, and also to determine the compatibility of the meteorological parameters in Egypt with the safety operating conditions (SOC) of PV-modules. The project viability analysis is performed using RETScreen version 4.0 software through electric energy production analysis, financial analysis, and GHG emission analysis. The study show that placement of the proposed 10 MW PV-grid connected power plant at Wahat Kharga site offers the highest profitability, energy production, and GHG emission reduction. The lowest profitability and energy production values are offered at Safaga site. Therefore, it is recommended to start building large-scale PV power plants projects at Wahat Kharga site.

10/02883 Viability of solar photovoltaics as an electricity generation source for Jordan

Hrayshat, E. S. *Renewable Energy*, 2009, 34, (10), 2133–2140.

Viability of solar photovoltaics as an electricity generation source for Jordan was assessed utilizing a proposed 5 MW grid-connected solar photovoltaic power plant. Long-term (1994–2003) monthly average daily global solar radiation and sunshine duration data for 24 locations – distributed all over the country – were studied and analysed to assess the distribution of radiation and sunshine duration over Jordan, and formed an input data for evaluation and analysis of the proposed plant's electricity production and economic feasibility. It was found that – depending on the geographical location – the global solar radiation on horizontal surface varied between 1.51 and 2.46 MWh/m^2/year with an overall mean value of 2.01 MWh/m^2/year for Jordan. The sunshine duration was found to vary – according to the location – between 8.47 and 9.68 h/day, with a mean value of 9.07 h/day and about 3311 sunshine hours annually for Jordan. The annual electricity production of the proposed plant varied depending on the location between 6.886 and 11.919 GWh/year, with a mean value of 9.46 GWh/year. The specific yield varied between 340.9 and 196.9 kWh/m^2, while the mean value was 270.59 kWh/m^2. Analysis of the annual electricity production of the plant, the specific yield, besides the economic indicators i.e. internal rate of return, simple payback period, years-to-positive cash flow, net present value, annual life cycle saving, benefit–cost ratio, and cost of energy – for all sites – showed that Tafila and Karak are the most suitable sites for the solar photovoltaic power plant's development and Wadi Yabis is the worst. The results also showed that an average of 7414.9 tons of greenhouse gases can be avoided annually utilizing the proposed plant for electricity generation at any part of Jordan.

Wind energy

10/02884 A brief status on condition monitoring and fault diagnosis in wind energy conversion systems

Amirat, Y. *et al. Renewable and Sustainable Energy Reviews*, 2009, 13, (9), 2629–2636.

There is a constant need for the reduction of operational and maintenance costs of wind energy conversion systems (WECSs). The most efficient way of reducing these costs would be to continuously monitor the condition of these systems. This allows for early detection of the degeneration of the generator health, facilitating a proactive response, minimizing downtime, and maximizing productivity. Wind generators are also inaccessible since they are situated on extremely high towers, which are normally 20 m or more in height. There are also plans to increase the number of offshore sites increasing the need for a remote means of WECS monitoring that eliminates some of the difficulties faced due to accessibility problems. Therefore and due to the importance of condition monitoring and fault diagnosis in WECS (blades, drive trains, and generators), and keeping in mind the need for future research, this paper is intended as a brief status describing different types of faults, their generated signatures, and their diagnostic schemes.

10/02885 Aero-elastic behavior of a flexible blade for wind turbine application: a 2D computational study

Hoogedoorn, E. *et al. Energy*, 2010, 35, (2), 778–785.

This paper presents a computational study into the static aeroelastic response of a 2D wind turbine airfoil under varying wind conditions. An efficient and accurate code that couples the X-Foil software for computation of airfoil aerodynamics and the MATLAB PDE toolbox for computation of the airfoil deformation is developed for the aero-elastic computations. The code is validated qualitatively against computational results in literature. The impact of a flexibility of the airfoil is studied for a range of design parameters including the free stream velocity, pitch angle, airfoil thickness, and airfoil camber. Static aero-elastic effects have the potential to improve lift and the lift over drag ratio at off-design wind speed conditions. Flexibility delays stall to a large pitch angle, increasing the operating range of a flexible blade airfoil. With increased thickness the airfoil deformation decrease only linearly.

10/02886 Assessing the wind energy potential projects in Algeria

Himri, Y. *et al. Renewable and Sustainable Energy Reviews*, 2009, 13, (8), 2187–2191.

A research program is under way in the SONELGAZ R&D Office with the aim of studying the potential of wind energy in Algeria. This paper presents an analysis of recently collected hourly wind data over a period of almost 5 years between 2002 and 2006, from four selected sites as well as preliminary evaluation of the wind energy potential. The results showed that Tindouf and Dély Brahim sites have higher wind energy potential with annual wind speed average of 5.8 and 5.7 m/s respectively at height of 17 m above ground level (AGL). The two sites are candidates for remote area wind energy applications. The Ouled Fayet and Marsa Ben M'hidi sites' wind speed data indicated that the two sites have lower annual wind speed averages between 3.9–4.7 m/s at 17 m AGL, which makes them candidates for the installation of windmills to provide water for drinking and small-scale irrigation purposes. This paper also includes a brief description of the equipment. Finally, this work is only a preliminary study in order to assess wind energy analysis in Algeria and give useful insights to engineers and experts dealing with wind energy.

10/02887 Decision analysis on generation capacity of a wind park

Kongnam, C. *et al. Renewable and Sustainable Energy Reviews*, 2009, 13, (8), 2126–2133.

The investment decision on generation capacity of a wind park is difficult when wind studies or data are neither available nor sufficient to provide adequate information for developing a wind power project. Although new measurement is possible but it is definitely time consuming. To determine the optimum capacity, decision analysis techniques are proposed in this paper to cope with uncertainties arising from wind speed distribution and power–speed characteristics. The wind speed distribution is modelled from the measured data, the

Rayleigh distribution, and the Weibull distribution. The power–speed curve of a wind turbine from cut-in speed to rated speed is modelled by using linear, parabolic, cubic, and quadratic characteristics. The optimization model is formulated as a mixed-integer nonlinear programming problem. The constraints are considered as interval bounds so that a set of feasible solutions is obtained. The optimum solution can be determined by using the profit-to-cost and profit-to-area ratios as performance metrics of investment. Decision analysis rules are then applied to overcome the uncertainty problem and to refine the investment plan. The proposed procedure has been tested with the wind power project of the Electricity Generating Authority of Thailand.

10/02888 Fuzzy neural network output maximization control for sensorless wind energy conversion system

Lin, W.-M. *et al. Energy*, 2010, 35, (2), 592–601.

This paper presents the design of an online training fuzzy neural network controller with a high-performance speed observer for the induction generator. The proposed output maximization control is achieved without mechanical sensors such as the wind speed or position sensor, and the new control system will deliver maximum electric power with light weight, high efficiency, and high reliability. The estimation of the rotor speed is designed on the basis of the sliding mode control theory.

10/02889 Landscape externalities from onshore wind power

Meyerhoff, J. *et al. Energy Policy*, 2010, 38, (1), 82–92.

The expansion of renewable energy is a central element of the German federal government's climate and energy policy. The target for 2020 is to produce 30% of the electricity from renewable energies. Wind power has been selected to be a major contributor to this change. Replacing old wind turbines by modern ones and building new turbines on land will be crucial in meeting this target. However, the expansion of onshore wind power is not universally accepted. In several regions of Germany, residents are protesting against setting up new wind turbines. To determine the negative effects two choice experiments were applied in Westsachsen and Nordhessen. In both regions the externalities of wind-power generation until 2020 based on today's state of technology were measured. The results show that negative landscape externalities would result from expanding wind power generation. Using latent class models three different groups of respondents experiencing different degrees of externalities were identified.

10/02890 Life cycle energy and greenhouse emissions analysis of wind turbines and the effect of size on energy yield

Crawford, R. H. *Renewable and Sustainable Energy Reviews*, 2009, 13, (9), 2653–2660.

Wind turbines, used to generate renewable energy, are typically considered to take only a number of months to produce as much energy as is required in their manufacture and operation. With a life expectancy of upwards of 20 years, the energy produced by wind turbines over their life can be many times greater than that embodied in their production. Many previous life cycle energy studies of wind turbines are based on methods of assessment now known to be incomplete. These studies may underestimate the energy embodied in wind turbines by more than 50%, potentially overestimating the energy yield of those systems and possibly affecting the comparison of energy generation options. With the increasing trend towards larger scale wind turbines, comes a respective increase in the energy required for their manufacture. It is important to consider whether or not these increases in wind turbine size, and thus embodied energy, can be adequately justified by equivalent increases in the energy yield of such systems. This paper presents the results of a life cycle energy and greenhouse emissions analysis of two wind turbines and considers the effect of wind turbine size on energy yield. The issue of incompleteness associated with many past life cycle energy studies is also addressed. Energy yield ratios of 21 and 23 were found for a small and large scale wind turbine, respectively. The embodied energy component was found to be more significant than in previous studies, emphasized here due to the innovative use of a hybrid embodied energy analysis approach. The life cycle energy requirements were shown to be offset by the energy produced within the first 12 months of operation. The size of wind turbines appears to not be an important factor in optimizing their life cycle energy performance.

10/02891 Model simplification and optimization of a passive wind turbine generator

Sareni, B. *et al. Renewable Energy*, 2009, 34, (12), 2640–2650.

In this paper, the design of a 'low cost full passive structure' of wind turbine system without active electronic part (power and control) is investigated. The efficiency of such device can be obtained only if the design parameters are mutually adapted through an optimization design approach. For this purpose, sizing and simulating models are developed to characterize the behaviour and the efficiency of the wind turbine system. A model simplification approach is presented, allowing the reduction of computational times and the investigation of multiple Pareto-optimal solutions with a multiobjective genetic algorithm. Results show that the optimized wind turbine configurations are capable of matching very closely the behaviour of active wind turbine systems which operate at optimal wind powers by using a maximum power point tracking (MPPT) control device.

10/02892 Numerical investigation of the influence of topography on simulated downburst wind fields

Mason, M. *et al. Journal of Wind Engineering and Industrial Aerodynamics*, 2010, 98, (1), 21–33.

A, dry, non-hydrostatic sub-cloud model is used to simulate an isolated stationary downburst wind event to study the influence topographic features have on the near-ground wind structure of these storms. It was generally found that storm maximum wind speeds could be increased by up to 30% because of the presence of a topographic feature at the location of maximum wind speeds. Comparing predicted velocity profile amplification with that of a steady flow impinging jet, similar results were found despite the simplifications made in the impinging jet model. Comparison of these amplification profiles with those found in the simulated boundary layer winds reveal reductions of up to 30% in the downburst cases. Downburst and boundary layer amplification profiles were shown to become more similar as the topographic feature height was reduced with respect to the outflow depth.

10/02893 Output power maximization of low-power wind energy conversion systems revisited: possible control solutions

Vlad, C. *et al. Energy Conversion and Management*, 2010, 51, (2), 305–310.

This paper discusses the problem of output power maximization for low-power wind energy conversion systems operated in partial load. These systems are generally based on multi-polar permanent-magnet synchronous generators, who exhibit significant efficiency variations over the operating range. Unlike the high-power systems, whose mechanical-to-electrical conversion efficiency is high and practically does not modify the global optimum, the low-power systems global conversion efficiency is affected by the generator behaviour and the electrical power optimization is no longer equivalent with the mechanical power optimization. The system efficiency has been analysed by using both the maxima locus of the mechanical power versus the rotational speed characteristics, and the maxima locus of the electrical power delivered versus the rotational speed characteristics. The experimental investigation has been carried out by using a torque-controlled generator taken from a real-world wind turbine coupled to a physically simulated wind turbine rotor. The experimental results indeed show that the steady-state performance of the conversion system is strongly determined by the generator behaviour. Some control solutions aiming at maximizing the energy efficiency are envisaged and thoroughly compared through experimental results.

10/02894 Power curve control in micro wind turbine design

Lanzafame, R. and Messina, M. *Energy*, 2010, 35, (2), 556–561.

In this work, a micro wind turbine will be designed and built for a series of wind tunnel tests (rotor dynamics and wind turbine (WT) start-up velocity). Its design stems from an original numerical code, developed by the authors, based on the blade element momentum (BEM) Theory. From classic design criteria, having evaluated all the geometric characteristics, an innovative methodology will be shown for controlling the power curve of the wind turbine. Indications will be supplied in order to modify various sections of the power curve and so as to design the turbine according to its practical application.

10/02895 The application of artificial neural networks to mapping of wind speed profile for energy application in Nigeria

Fadare, D. A. *Applied Energy*, 2010, 87, (3), 934–942.

Modelling and prediction of wind speed are essential prerequisites in the sitting and sizing of wind power applications. The profile of wind speed in Nigeria is modelled using artificial neural network (ANN). The ANN model consists of three-layered, feed-forward, back-propagation network with different configurations, designed using the Neural Toolbox for MATLAB. The monthly mean daily wind speed data monitored at 10 m above ground level for a period of 20 years (1983–2003) for 28 ground stations operated by the Nigeria Meteorological Services (NIMET) were used as training (18 stations) and testing (10 stations) dataset. The geographical parameters (latitude, longitude and altitude) and the month of the year were used as input data, while the monthly mean wind speed was used as the output of the network. The optimum network architecture with minimum mean absolute percentage error (MAPE) of 8.9% and correlation coefficient

(r) between the predicted and the measured wind speed values of 0.9380 was obtained. The predicted monthly wind speed ranged from 0.9–13.1 m/s with an annual mean of 4.7 m/s. The model-predicted wind speed values are given in the form of monthly maps, which can be easily used for assessment of wind energy potential for different locations within Nigeria.

10/02896 The role of taxation policy and incentives in wind-based distributed generation projects viability: Ontario case study

Albadi, M. H. and El-Saadany, E. F. *Renewable Energy*, 2009, 34, (10), 2224–2233.

Taxation policy and incentives play a vital role in wind-based distributed generation projects viability. In this paper, a thorough techno-economical evaluation of wind-based distributed generation projects is conducted to investigate the effect of taxes and incentives in the economic viability of investments in this sector. This paper considers the effects of Provincial income taxes, capital cost allowance (CCA), property taxes, and wind power production Federal incentives. The case study is conducted for different wind turbines and wind speed scenarios. Given turbine and wind speed data, the capacity factor (CF) of each turbine and wind speed scenario was calculated. Net present value (NPV) and internal rate of return (IRR) for different scenarios were then used to assess the project's viability considering Ontario Standard Offer Program for wind power.

10/02897 Uncertainty analysis of wind energy potential assessment

Kwon, S.-D. *Applied Energy*, 2010, 87, (3), 856–865.

This study presents a framework to assess the wind resource of a wind turbine using uncertainty analysis. Firstly, probability models are proposed for the natural variability of wind resources that include air density, mean wind velocity and associated Weibull parameters, surface roughness exponent, and error for prediction of long-term wind velocity based on the measure–correlate–predict method. An empirical probability model for a power performance curve is also demonstrated. Secondly, a Monte-Carlo based numerical simulation procedure which utilizes the probability models is presented. From the numerical simulation, it is found that the present method can effectively evaluate the expected annual energy production for different averaging periods and confidence intervals. The uncertainty, which is 11% corresponding to the normalized average energy production in the present example, can be calculated by specifically considering the characteristics of the individual sources in terms of probability parameters.

10/02898 Wind characteristics and wind energy potential in western Nevada

Belu, R. and Koracin, D. *Renewable Energy*, 2009, 34, (10), 2246–2251.

The wind potential in western Nevada was assessed by using wind, temperature, and pressure data over a period of four and half years from four 50 m tall towers. The seasonal wind patterns for all towers show a maximum during the spring season. Diurnal wind speed patterns for all seasons and months showed a minimum during the late morning and a maximum during the late afternoon. The highest values are during the spring season with multi-annual hourly wind speeds at or above 8 m/s and relative frequency of the wind speed in the optimum turbine range (5–25 m/s) of 70% or higher for the Tonopah tower, with lower values for the other three towers. The monthly power law index values are lower than the standard value 0.147 (in general 0.13 or lower). The hourly turbulence intensities were higher at lower elevations, with values of about 0.35 or higher at the 10 m level and at lower wind speed range (5.0 m/s or less). Higher turbulence intensities were found for all towers and heights during the spring and summer seasons and lower values during the rest of the year. The daily gust factor for the 2003–2007 composite data sets shows low probabilities (2% or less) of the wind gusts exceeding 25 m/s.

10/02899 Wind energy in China: current scenario and future perspectives

Xia, C. and Song, Z. *Renewable and Sustainable Energy Reviews*, 2009, 13, (8), 1966–1974.

Wind power in China registered a record level of expansion recently, and has doubled its total capacity every year since 2004. Many experts believe that China will be central to the future of the global wind energy market. Consequently, the growth pattern of wind power in China may be crucial to the further development of the global wind market. This paper firstly presented an overview of wind energy potential in China and reviewed the national wind power development course in detail. Based on the installed wind capacity in China over the past 18 years and the technical potential of wind energy resources, the growth pattern was modelled in this study for the purpose of prospect analysis, in order to obtain projections concerning the development potential. The future perspectives of wind energy development in China are predicted and analysed. This study provides a comprehensive overview of the current status of wind power in China and some insights into the prospects of China's wind power market, which is emerging as a new superpower in the global wind industry.

10/02900 Wind turbine generator systems. The supply chain in China: status and problems

He, Y. and Chen, X. *Renewable Energy*, 2009, 34, (12), 2892–2897.

Wind turbine generator systems (WTGS) manufacture is booming in China. The key to success of the wind turbine generator industry is to construct the supply chain. However few papers focus on the supply chain. In China, many enterprises have started to manufacture the wind turbine generator system and the components. The supply chain of the wind turbine generator system is not well established in China. Many key components of WTGS still need to be imported, such as the principal axis bearing and electrical control systems. The authors review the status of wind turbine generator system manufacturing and analyse the problems of the supply chain in China. They also analyse the problems about the supply chain from a macroscopic view. The aims of this paper are to let more scholars and experts know the status of the WTGS supply chain and to do something for building a successful industry in China.

Others, including economics

10/02901 A current and future state of art development of hybrid energy system using wind and PV-solar: a review

Nema, P. *et al. Renewable and Sustainable Energy Reviews*, 2009, 13, (8), 2096–2103.

The wind and solar energy are omnipresent, freely available, and environmental friendly. The wind energy systems may not be technically viable at all sites because of low wind speeds and being more unpredictable than solar energy. The combined utilization of these renewable energy sources are therefore becoming increasingly attractive and are being widely used as alternative of oil-produced energy. Economic aspects of these renewable energy technologies are sufficiently promising to include them for rising power generation capability in developing countries. A renewable hybrid energy system consists of two or more energy sources, a power conditioning equipment, a controller and an optional energy storage system. These hybrid energy systems are becoming popular in remote area power generation applications due to advancements in renewable energy technologies and substantial rise in prices of petroleum products. Research and development efforts in solar, wind, and other renewable energy technologies are required to continue for, improving their performance, establishing techniques for accurately predicting their output and reliably integrating them with other conventional generating sources. The aim of this paper is to review the current state of the design, operation and control requirement of the stand-alone PV solar–wind hybrid energy systems with conventional backup source i.e. diesel or grid. This Paper also highlights the future developments, which have the potential to increase the economic attractiveness of such systems and their acceptance by the user.

10/02902 A dynamic inexact energy systems planning model for supporting greenhouse-gas emission management and sustainable renewable energy development under uncertainty – a case study for the City of Waterloo, Canada

Lin, Q. G. and Huang, G. H. *Renewable and Sustainable Energy Reviews*, 2009, 13, (8), 1836–1853.

In this study, a dynamic interval-parameter community-scale energy systems planning model (DIP-CEM) was developed for supporting greenhouse-gas emission (GHG) management and sustainable energy development under uncertainty. The developed model could reach insight into the interactive characteristics of community-scale energy management systems, and thus capable of addressing specific community environmental and socio-economic features. Through integrating interval-parameter and mixed-integer linear programming techniques within a general optimization framework, the DIP-CEM could address uncertainty (expressed as interval values) existing in related costs, impact factors and system objectives as well as facilitate dynamic analysis of capacity-expansion decisions under such a uncertainty. DIP-CEM was then applied to the City of Waterloo, Canada to demonstrate its applicability in supporting decisions of community energy systems planning and GHG-emission reduction management. One business-as-usual (BAU) case and two GHG-emission reduction cases were analysed with desired plans of GHG-emission reduction. The results indicated that the developed DIP-CEM could help provide sound strategies for dealing with issues of sustainable energy development and GHG-emission reduction within an energy management system.

10/02903 A light left in the dark: the practice and politics of pico-hydropower in the Lao PDR

Smits, M. and Bush, S. R. *Energy Policy*, 2010, 38, (1), 116–127.
The article describes the widespread use of an estimated 60,000 low-head pico-hydropower turbines and well-developed networks of supply and support in the northern part of the Laos. This apparent widespread use is contrasted with the policy narratives of key actors in the government, multilateral organizations and the private sector which show an often simplified and overly negative attitude towards pico-hydropower. Based on empirical research carried out in three upland districts and the capital, Vientiane, the paper critically investigates the apparent disjuncture between policy and practice by placing pico-hydropower within the broader political context of rural electrification in the Laos. It is argued that the neglect of pico-hydropower and other off-grid household electrification technologies is a result of an endemic lack of information on which to base policy decisions, the orientation of the government to facilitate large scale foreign investment in large hydropower dams, the universal applicability of solar home systems, and the broader state agenda of centralization and control over service provision to remote upland areas.

10/02904 A review of renewable energy technologies integrated with desalination systems

Eltawil, M. A. *et al. Renewable and Sustainable Energy Reviews*, 2009, 13, (9), 2245–2262.
This paper presents a review of the highlights of the most important efforts in the field of desalination by renewable energies, with emphasis on technologies and economics. The review also includes water sources, demand, availability of potable water and purification methods. The classification of distillation units has been done on the basis of literature survey until today. A comparative study between different renewable energy technologies powered desalination systems as well as economics have been done. The real problem in these technologies is the optimum economic design and evaluation of the combined plants in order to be economically viable for remote or arid regions. Wind energy technology is cheaper than the conventional ones, and used extensively around the world. The slow implementation of renewable energy projects especially in the developing countries are mostly due to the governments subsides of conventional fuels products and electricity. The economic analyses carried out so far have not been able to provide a strong basis for comparing economic viability of each desalination technology. The economic performances expressed in terms of cost of water production have been based on different system capacity, system energy source, system component, and water source. These differences make it difficult, if not impossible, to assess the economic performance of a particular technology and compare it with others. Reverse osmosis is becoming the technology of choice with continued advances being made to reduce the total energy consumption and lower the cost of water produced.

10/02905 Advanced exergetic analysis of a novel system for generating electricity and vaporizing liquefied natural gas

Tsatsaronis, G. and Morosuk, T. *Energy*, 2010, 35, (2), 820–829.
LNG technology has been in use since the 1960s. During the last 20 years the total cost of LNG technology has decreased by 30% due mainly to improvements of the liquefaction process and shipping. However, the regasification system has not been significantly improved. The paper presents a detailed advanced exergetic analysis of a novel co-generation concept that combines LNG regasification with the generation of electricity. The analysis includes splitting the exergy destruction within each component into its unavoidable, avoidable, endogenous and exogenous parts as well as a detailed splitting of the avoidable exogenous exergy destruction. The results of the advanced exergetic analysis are confirmed through a sensitivity analysis. Finally, some suggestions for improving the overall system efficiency are developed.

10/02906 An analysis of feed-in tariff remuneration models: implications for renewable energy investment

Couture, T. and Gagnon, Y. *Energy Policy*, 2010, 38, (2), 955–965.
Recent experience from around the world suggests that feed-in tariffs (FITs) are the most effective policy to encourage the rapid and sustained deployment of renewable energy. There are several different ways to structure a FIT policy, each with its own strengths and weaknesses. This paper presents an overview of seven different ways to structure the remuneration of a FIT policy, divided into two broad categories: those in which remuneration is dependent on the electricity price, and those that remain independent from it. This paper examines the advantages and disadvantages of these different FIT models, and concludes with an analysis of these design options, with a focus on their implications both for investors and for society.

10/02907 Bioenergy industries development in China: dilemma and solution

Zhang, P. *et al. Renewable and Sustainable Energy Reviews*, 2009, 13, (9), 2571–2579.
Having 2.8×10^8–3.0×10^8 t/a of wood energy, 4.0×10^6 t/a of oil seeds, 7.7×10^8 t/a of crops straw, 3.97×10^9 t/a of poultry and livestock manure, 1.48×10^8 t/a of municipal waste, and 4.37×10^{10} t/a of organic wastewater, China is in possession of good resource conditions for the development of bioenergy industries. Until the end of 2007, China has popularized 2.65×10^7 rural household biogas, established 8318 large and middle-scale biogas projects, and produced 1.08×10^{10} m^3/a of biogas; the production of bioethanol, biodiesel, biomass briquettes fuel and biomass power generation reached to 1.5×10^6 t/a, 3.0×10^5 t/a, 6.0×10^4 t/a and 6.42×10^9 kWh, respectively. In recent years, bioenergy industries developed increasingly fast in China. However, the industrial base was weak with some dilemma existing in raw material supply, technological capability, industry standards, policy and regulation, and follow-up services, etc. From the viewpoint of long-term effective development system for bioenergy industries in China, a series of policy suggestions have been offered, such as strengthening strategy research, improving bioenergy industries development policies and plan, enhancing scientific research input, persisting in technology innovation, establishing product quality standard, improving industrial standard system, opening market and accelerating commercialization, etc. It is expected that the advices mentioned above could be helpful for the improvement of bioenergy industries development.

10/02908 Bioenergy revisited: key factors in global potentials of bioenergy

Dornburg, V. *et al. Energy & Environmental Science*, 2010, 3, (3), 258–67.
This article assesses the current knowledge on biomass resource potentials and interrelated factors such as water availability, biodiversity, food demand, energy demand and agricultural commodity markets. A sensitivity analysis of the available information narrows the range of biomass potentials from 0–1500 to approximately 200–500 EJ/yr in 2050. In determining the latter range, water limitations, biodiversity protection and food demand are taken into consideration. Key factors are agricultural efficiency and crop choice. In principle, global biomass potentials could meet up to one-third of the projected global energy demand in 2050.

10/02909 Competition between biofuels: modeling technological learning and cost reductions over time

de Wit, M. *et al. Biomass and Bioenergy*, 2010, 34, (2), 203–217.
A key aspect in modelling the (future) competition between biofuels is the way in which production cost developments are computed. The objective of this study was threefold: (i) to construct a (endogenous) relation between cost development and cumulative production (ii) to implement technological learning based on both engineering study insights and an experience curve approach, and (iii) to investigate the impact of different technological learning assumptions on the market diffusion patterns of different biofuels. The analysis was executed with the European biofuel model BioTrans, which computes the least cost biofuel route. The model meets an increasing demand, reaching a 25% share of biofuels of the overall European transport fuel demand by 2030. Results show that first-generation biodiesel is the most cost competitive fuel, dominating the early market. With increasing demand, modestly productive oilseed crops become more expensive rapidly, providing opportunities for advanced biofuels to enter the market. While biodiesel supply typically remains steady until 2030, almost all additional yearly demands are delivered by advanced biofuels, supplying up to 60% of the market by 2030. Sensitivity analysis shows that: (i) overall increasing investment costs favour biodiesel production, (ii) separate gasoline and diesel subtargets may diversify feedstock production and technology implementation, thus limiting the risk of failure and preventing lock-in and (iii) the moment of an advanced technology's commercial market introduction determines, to a large degree, its future chances for increasing market share.

10/02910 Design charts for impulse turbine wave energy extraction using experimental data

Thakker, A. *et al. Renewable Energy*, 2009, 34, (10), 2264–2270.
This study presents newly developed charts to aid in early design of impulse turbine for wave energy extraction. These charts, based on the available experimental data, represent a simple approach to the performance evaluation of the turbine. The novel approach is applied in a case study that considers the optimum diameter design selection of next-generation impulse turbine power take-off. This allowed the selection of the correct impulse turbine sizing for a required rated

power. The result is consistent for such an application, where the optimum rotor diameter would be 1.6 m for a maximum rated power of 400 kW.

10/02911 Harnessing biofuels: a global renaissance in energy production?

Jegannathan, K. R. *et al. Renewable and Sustainable Energy Reviews*, 2009, 13, (8), 2163–2168.

Biofuel, peoples' long awaiting alternative fuel, is yet to struggle a long way to reach in retail outlet all over the world as an economical and environmental friendly fuel. Biofuels include bioethanol, biodiesel, biogas, bio-synthetic gas (bio-syngas), bio-oil, bio-char, Fischer–Tropsch liquids, and biohydrogen. Among these bioethanol, biodiesel, biogas are predominant which can be produced either using chemical catalyst or biocatalyst from biomass. At present, the conventional process involves the chemical catalyst while a rigorous research is focused on using a biocatalyst. This review brings out the advantages and disadvantages of using different type of catalyst in biofuel production and emphasis on new technologies as an alternative to conventional technologies.

10/02912 Inequalities and externalities of power sector: a case of Broadlands hydropower project in Sri Lanka

Prasanthi Gunawardena, U. A. D. *Energy Policy*, 2010, 38, (2), 726–734.

The objective of the paper is to estimate environmental externalities related to a run of river project in Sri Lanka and to investigate inequity in distribution of impacts among different social groups. Diversion of the river resulted in loss of water sports (for high-income groups both local and remote), loss of historical monuments (for remote high-income groups) and recreation losses (for local poor). Removal of forest cover leads to loss of non-timber products (for local poor) and carbon storage (for remote high- and low-income groups). Loss of home garden productivity was borne by local poor groups. Benefit of the project, generation of 145 GWh annually, was a gain for the grid connected groups. The impacts were valued using various valuation methods. The base case of the cost benefit analysis resulted in NPV of US$11,335,730. When distributional weights are applied for different income groups, both the sign and magnitude of net benefits change. In order to be viable, the project needs diversion of at least 9% of generated electricity to the poorest households in the country. Implications for energy policy towards reducing externality and inequality impacts are also discussed.

10/02913 Modeling representations of canola oil catalytic cracking for the production of renewable aromatic hydrocarbons

Sadrameli, S. M. *et al. Journal of Analytical and Applied Pyrolysis*, 2009, 86, (1), 1–7.

The US Environmental Protection Agency (EPA) banned lead in motor gasoline in 1996. Aviation gasoline was not included in the ban but due to the environmental pollution, the industry is looking for unleaded replacement fuels with a high octane number. Catalytic cracking of renewable biomass-derived raw materials such as vegetable oils could convert them into valuable raw materials such as aromatic hydrocarbons which can be added to the motor and aviation gasoline fuels for the octane number enhancement. This paper distills the systematics of a large number of experimental yields data of canola oil catalytic cracking using HZSM-5 catalyst, for the production of renewable aromatic hydrocarbons obtained at University of Saskatchewan (USK), Canada. The products were mainly gases, organic liquid products (OLPs) and solid coke. The large body of data is organized using an analytical semi-empirical model (ASEM) developed at the University of Florida (UF) that provides a reasonable account using only a small number of adjusted parameters. The model fits very well with the experimental data in the temperature range of 200–600 °C. The influence of catalyst types on the conversion of canola oil to aromatic hydrocarbons is also discussed. The analytical methodology should be useful for organizing catalytic cracking yields of other materials containing carbon, hydrogen and oxygen.

10/02914 Political will and collaboration for electric power reform through renewable energy in Africa

Chineke, T. C. and Ezike, F. M. *Energy Policy*, 2010, 38, (1), 678–684.

Climate change, in particular rainfall variability, affects rain-dependent agriculture in Africa. The resulting food shortages, in combination with rising population and lack of access to electricity needed for development, require the governments and people of Africa to consider renewable energy sources. One example that has high potential in Africa is solar energy. Many African governments have begun discussions about renewable energy but tangible results have yet to materialize. This research contributes to the governmental efforts by presenting the solar electricity potentials for some African cities. Using photovoltaic geographical information system (PVGIS) data, it is clear that there is enough electricity for urban and rural dwellers if there is political will and if the solar panels are mounted at the suggested optimal angles ranging from 8–34°. The solar irradiation at all sites was higher than the typical daily domestic load requirement of 2324 Wh/m^2 in urban and rural areas. The authors provide a strong rationale for political will, collaboration and transparent energy policies that will ensure that life is enhanced through the use of environmentally-friendly renewable energy technologies such as solar power.

10/02915 Renewable energy consumption and economic growth: evidence from a panel of OECD countries

Apergis, N. and Payne, J. E. *Energy Policy*, 2010, 38, (1), 656–660.

This study examines the relationship between renewable energy consumption and economic growth for a panel of 20 OECD countries over the period 1985–2005 within a multivariate framework. Given the relatively short span of the time series data, a panel cointegration and error correction model is employed to infer the causal relationship. The heterogeneous panel cointegration test reveals a long-run equilibrium relationship between real GDP, renewable energy consumption, real gross fixed capital formation, and the labour force with the respective coefficients positive and statistically significant. The Granger-causality results indicate bidirectional causality between renewable energy consumption and economic growth in both the short and long run.

10/02916 Renewable energy resources and technologies applicable to Ireland

Rourke, F. O. *et al. Renewable and Sustainable Energy Reviews*, 2009, 13, (8), 1975–1984.

The energy consumed in Ireland is primarily achieved by the combustion of fossil fuels. Ireland's only indigenous fossil fuel is peat; all other fossil fuels are imported. As fossil fuels continually become more expensive, their use as an energy source also has a negative impact on the environment. Ireland's energy consumption can be separated into three divisions: transportation, electricity generation and heat energy. Ireland however has a vast range of high quality renewable energy resources. Ireland has set a target that 33% of its electricity will be generated from renewable sources by 2020. The use of biomass, wind and ocean energy technologies is expected to play a major part in meeting this target. The use of renewable energy technologies will assist sustainable development as well as being a solution to several energy related environmental problems. This paper presents the current state of renewable energy technologies and potential resources available in Ireland. Considering Ireland's present energy state, a future energy mix is proposed.

10/02917 Review and comparison study of hybrid diesel/solar/hydro/fuel cell energy schemes for a rural ICT Telecenter

Abdullah, M. O. *et al. Energy*, 2010, 35, (2), 639–646.

In this paper, the rural electrification study of an ICT Telecenter in particular reference to the Kelabit Highland of Sarawak is presented. The use of diesel generator and its associated environmental implications is first discussed. The cost-effectiveness of the present solar PV system and the solar/hydro schemes for rural electrification of the rural ICT are evaluated employing the HOMER simulation software, considering sustainability factors such as system efficiency, weather, fuel costs, operating and maintaining costs. Subsequently, simple novel hybrid energy performance equations and the associated energy performance curves are derived and introduced, respectively, which provide a visualization model, simplifying hybrid system analysis. Results obtained in this study have shown that combined power schemes is more sustainable in terms of supplying electricity to the Telecenter compared to a stand-alone PV system due to prolong cloudy and dense haze periods. The hybrid systems can have efficiency range of approximately 15%–75% compared to PV stand-alone of only approximately 10%, indicating hybrid systems are more reliable and sustainable – in minimizing both energy losses and excess energy.

10/02918 Scheduling of head-dependent cascaded hydro systems: mixed-integer quadratic programming approach

Catalão, J. P. S. *et al. Energy Conversion and Management*, 2010, 51, (3), 524–530.

This paper investigates the problem of short-term hydro scheduling, particularly concerning head-dependent cascaded hydro systems. The authors propose a novel mixed-integer quadratic programming approach, considering not only head-dependency, but also discontinuous operating regions and discharge ramping constraints. Thus, an enhanced short-term hydro scheduling is provided due to the more realistic modelling presented in this paper. Numerical results from two case studies, based on Portuguese cascaded hydro systems, illustrate the proficiency of the proposed approach.

10/02919 Simulation and optimization of stand-alone hybrid renewable energy systems

Bernal-Agustín, J. L. and Dufo-López, R. *Renewable and Sustainable Energy Reviews*, 2009, 13, (8), 2111–2118.

Stand-alone hybrid renewable energy systems usually incur lower costs and demonstrate higher reliability than photovoltaic (PV) or wind systems. The most usual systems are PV–wind–battery and PV–diesel–battery. Energy storage is usually in batteries (normally of the lead-acid type). Another possible storage alternative, such as hydrogen, is not currently economically viable, given the high cost of the electrolysers and fuel cells and the low efficiency in the electricity–hydrogen–electricity conversion. When the design of these systems is carried out, it is usually done resolve an optimization problem in which the net present cost is minimized or, in some cases, in relation to the levelized cost of energy. The correct resolution of this optimization problem is a complex task because of the high number of variables and the non-linearity in the performance of some of the system components. This paper revises the simulation and optimization techniques, as well as the tools existing that are needed to simulate and design stand-alone hybrid systems for the generation of electricity.

10/02920 Sustainable energy planning based on a stand-alone hybrid renewable energy/hydrogen power system: application in Karpathos island, Greece

Giatrakos, G. P. *et al. Renewable Energy*, 2009, 34, (12), 2562–2570.

This study presents the sustainable planning of a renewables-based energy system, which aims to fulfil the electric needs of the island by replacing the existing diesel generators with new wind farms, photovoltaic installations and hydrogen production systems. Electric system design and least cost planning analysis were concluded using historic data from both demand and supply sides. An optimal 'sustainable island' scheme should ensure 100% use of renewable energy resources for power generation, while hydrogen production is ideal for covering storage and transportation needs. Due to its morphology and scale, Karpathos applies perfectly for wind and solar energy systems, due to increased solar resource (about 1790 kWh/m^2 year of global irradiation) and high wind potential (average of 9 m/s in specific locations). Therefore, this case study examines an increase in RES penetration up to 20% in the electric energy mixture, a hydrogen production plan just for the needs of transport and a more aggressive, 100% renewables scheme that ensures a self-fulfilling energy system based on indigenous renewable resources.

10/02921 The diffusion of renewable electricity in the presence of climate policy and technology learning: the case of Sweden

Pettersson, F. and Söderholm, P. *Renewable and Sustainable Energy Reviews*, 2009, 13, (8), 2031–2040.

The overall objective of this paper is to analyse the impact of climate policy and technology learning on future investments in the Swedish power sector. The authors assess the lifetime engineering costs of different power generation technologies in Sweden, and analyse the impact of carbon pricing on the competitive cost position of these technologies under varying rate-of-return requirements. They also argue that technological learning in the Swedish power sector – not the least in the case of wind power – is strongly related to the presence of international learning and R&D spillovers, and for this reason capacity expansions abroad have important influences of the future cost of power generation in Sweden. The results suggest that renewable power will benefit from existing EU climate policy measures, but overall additional policy instruments (e.g. green certificate schemes) are also needed to stimulate the diffusion of renewable power. Moreover, under a recent European Commission scenario and using estimated learning rates for wind power and the combined cycle gas turbine (CCGT), wind power gains considerable competitive ground due to international technology learning impacts. These latter results are, however, very sensitive to the assumed learning-by-doing rates for wind power and CCGT, respectively.

10/02922 The impact of tidal stream turbines on large-scale sediment dynamics

Neill, S. P. *et al. Renewable Energy*, 2009, 34, (12), 2803–2812.

Tidal stream turbines are exploited in regions of high tidal currents. Such energy extraction will alter the hydrodynamics of a tidal region, analogous to increasing the bed friction in the region of extraction. In addition, this study demonstrates that energy extracted with respect to tidal asymmetries due to interactions between quarter (M_4) and semi-diurnal (M_2) currents will have important implications for large-scale sediment dynamics. Model simulations show that energy extracted from regions of strong tidal asymmetry will have a much more pronounced effect on sediment dynamics than energy extracted from regions of tidal symmetry. The results show that energy extracted from regions of strong tidal asymmetry led to a 20% increase in the magnitude of bed level change averaged over the length of a large estuarine system, compared with energy extracted from regions of tidal symmetry. However, regardless of the location of a tidal stream farm within a tidal system, energy extraction reduces the overall magnitude of bed level change in comparison with non-extraction cases. This has practical application to many areas surrounding the UK, including the Irish Sea and the Bristol Channel, that exhibit strong tidal currents suitable for exploitation of the tidal stream resource, but where large variations in tidal asymmetry occur.

10/02923 Variability reduction through optimal combination of wind/wave resources – an Irish case study

Fusco, F. *et al. Energy*, 2010, 35, (1), 314–325.

This study presents a methodology to assess the possible benefits of the combination of wind energy with the still unexploited, but quite significant in Ireland, wave energy. An analysis of the raw wind and wave resource at certain locations around the coasts of Ireland shows how they are very low correlated on the south and west coast, where the waves are dominated by the presence of high energy swells generated by remote westerly wind systems. As a consequence, the integration of wind and waves in combined farms, at these locations, allows the achievement of a more reliable, less variable and more predictable electrical power production. The resulting benefits are particularly clear in the case of a relatively small and quite isolated electrical system such as the Irish one. Here, in fact, high levels of wind penetration strongly increase the requirement of surplus capacity and cause a much lower efficiency for conventional thermal plants.

10/02924 Wave energy in China: current status and perspectives

Zhang, D. *et al. Renewable Energy*, 2009, 34, (10), 2089–2092.

The progress in wave energy technologies in China during the past decade is briefly reviewed. And the description is focused on the wave energy resource and the current status of wave energy in China. The difficulties facing wave energy developments in China are summarized. The national policy of wave energy developments is outlined and perspectives of wave energy in China are discussed.

10/02925 Wave power potential along the Atlantic coast of the southeastern USA

Defne, Z. *et al. Renewable Energy*, 2009, 34, (10), 2197–2205.

The wave power potential along the southeast Atlantic coast of the USA bounded by latitudes 27°N and 38°N and longitudes 82°W and 72°W (i.e. North Carolina, South Carolina, Georgia, and northern Florida) is investigated in this study. The available data from National Data Buoy Center wave stations in the given area are examined. Temporal trends of the wave heights, wave periods and the wave power are analysed for a time scale of weeks. The time series from the wave stations are downsampled with a 15-day moving average filter with near 50% overlapping to study the seasonal trends. Power calculated from hourly significant wave heights and average wave periods is compared to power calculated using spectral wave density. It is found that a factor of 0.61 needs to be applied to the wave power calculated from hourly significant wave heights and average periods in order to get the same results with the power calculated from spectral wave density. The mean power within 50 km of the shore is determined to be ~9 kW/m, whereas higher power (~15 kW/m) is available further offshore.

14 FUEL SCIENCE AND TECHNOLOGY

Fundamental science, analysis, instrumentation

10/02926 A methodology to generate statistically dependent wind speed scenarios

Morales, J. M. *et al. Applied Energy*, 2010, 87, (3), 843–855.

Wind power – a renewable energy source increasingly attractive from an economic viewpoint – constitutes an electricity production alternative of growing relevance in current electric energy systems. However, wind power is an intermittent source that cannot be dispatched at the will of the producer. Modelling wind power production requires characterizing wind speed at the sites where the wind farms are located. The wind speed at a particular location can be described through a stochastic process that is spatially correlated with the stochastic processes describing wind speeds at other locations. This paper provides a methodology to characterize the stochastic processes pertaining to wind speed at different geographical locations via scenarios. Each one of these scenarios embodies time dependencies and is spatially dependent of the scenarios describing other wind stochastic processes. The scenarios generated by the proposed methodology are intended to be used within stochastic programming decision models to make informed decisions pertaining to wind power production. The methodology proposed is accurate in reproducing wind speed historical series as well as computationally efficient. A comprehensive case study is used to illustrate the capabilities of the proposed methodology. Appropriate conclusions are finally drawn.

10/02927 Absorbed impact energy and mode of fracture: a statistical description of the micro-structural dispersion

Pontikis, V. and Gorse, D. *Journal of Nuclear Materials*, 2009, 394, (1), 109–113.

A statistical model is proposed to account for the influence of the dispersion of the microstructure on the ductile-to-brittle transition in body-centred cubic (bcc) metals and their alloys. In this model, the dispersion of the microstructure is expressed via a normal distribution of transition temperatures whereas a simple relation exists between the values of absorbed, lower and upper shelf energies, the ductile area fraction and the distribution parameters. It is shown that via an appropriate renormalization of energies and temperatures, experimental data for different materials and ageing conditions align all together on a master curve, guaranteeing thereby the effectiveness of the proposed statistical description.

10/02928 Calculating indoor natural illuminance in overcast sky conditions

De Rosa, A. *et al. Applied Energy*, 2010, 87, (3), 806–813.

The work shows how natural illuminance values inside buildings depend on the calculation method of the sky luminance distribution implemented in the computer code which, for a room of fixed geometry and characteristics, transforms the outdoor meteorological data into indoor illuminance data. By means of the INLUX calculation code, experimentally validated, 12 different calculation methods of sky luminance distribution were compared, sometimes obtaining strong differences among the calculated values of indoor illuminance. The choice of some methods instead of others depends on the meteorological data available in the place considered. Comparing the calculated illuminances with the experimental values measured inside a scale model (1:5), located outdoors in Osaka (Japan), and exposed to daylight, the best calculation methods, among those considered, of sky luminance under overcast sky conditions were identified.

10/02929 China's oil use, 1990–2008

Leung, G. C. K. *Energy Policy*, 2010, 38, (2), 932–944.

Over the past two decades, China's oil demand has risen steeply. In 1990, it was only about 25% higher than that of 1978, the year economic reform was introduced. By 2008, it had reached 396.0 million tons, roughly four times the 1978 level, making China the second largest oil user worldwide. The country became a net oil importer in 1993, and between 1993 and 2008, its net import dependency – a yardstick for energy security – soared from 7.5% to 50.0%. China's increased demand for oil has made the country a global energy player of critical importance. Although the literature on the global implications of China's oil use has proliferated, relatively few studies have attempted to examine 'how China uses oil.' Hence, this study covers every oil-consuming facility and sector in China, exploring the patterns of, and factors involved in, oil demand by power plants, oil refineries, heat plants and, gas-works, and industrial, transport, agricultural, household and commercial sectors. It concludes that in virtually all sectors in China, oil demand will grow, with transport and industry leading the way.

10/02930 Designing sustainable recovery network of end-of-life products using genetic algorithm

Dehghanian, F. and Mansour, S. *Resources, Conservation and Recycling*, 2009, 53, (10), 559–570.

The objective of this paper is to design a sustainable recovery network, in which economical, environmental and social impacts are balanced. Life cycle analysis has been applied to investigate the environmental impact of different end-of-life options. Analytical hierarchy process has been utilized to calculate social impacts. Next in this research, a three-objective mathematical programming model has been developed to maximize economic and social benefits and minimize negative environmental impacts, simultaneously. Scrap tyres have been considered for a case study. Multi-objective genetic algorithm has been applied to find the Pareto-optimal solutions. In the recovery network of scrap tyres, each solution corresponds to a different configuration of the network, based on technology type and location of installed recycling plants. These Pareto-optimal solutions will give some trade-off information about the three mentioned objectives, so decision makers can assess the economical impact of efforts of improving the social and environmental issues.

10/02931 Fuzzy control model and simulation of supply air system in a test rig of low-temperature hot-water radiator system

Lu, Z. *et al. Energy and Buildings*, 2010, 42, (3), 386–392.

This paper proposes a typical multi-variable, large time delay and nonlinear system, self-extracting rules fuzzy control (SERFC) method to maintain a stable temperature value in a built environment chamber with supply air system and hot-water system. The parameters of the transfer functions in every control loop were identified by experimental data in a format of time sequences obtained from the experiment of dynamical responding performance. Fuzzy control simulations were implemented based on adjustment of the supply air system and hot-water system by SERFC. The simulation results show that SERFC for environment chamber has satisfied performance. There is no higher overshoot and stable error. The work presented in here can be used to deal with those complex thermal processes with difficulties in modelling of fuzzy control rules and provide a foundation for further application of fuzzy control in HVAC system.

10/02932 Genetic algorithm based correlations for heat transfer calculation on concave surfaces

Momayez, M. *et al. Applied Thermal Engineering*, 2009, 29, (17–18), 3476–3481.

Laboratory experiments were carried out on a boundary layer over a concave wall subject to Görtler instability in the presence of forced wavelengths. Measurements of the local heat transfer along the concave wall permit calculation of the local Stanton number St for various axial positions x, nominal velocity U_n, the wavelength λ and strength d_w of the forced initial perturbations. The relation among these variables was constructed by a phenomenological argument in the form of classical power law correlations: $\mathrm{St} = a\ (\mathrm{Re}_\theta)^b\ (x/R)^c\ (\lambda/\theta)^d$. Correlations constants are then derived by genetic algorithm methods. The calculated Stanton number is in good agreement with the experimental results. This study proposes correlations for the calculation of heat transfer on concave surfaces (such as gas turbine blade pressure side) where the flow is complex due to the presence of streamwise vortices.

10/02933 Mathematical model for the choice of an energy management structure of complex buildings

Hoinka, K. and Ziębik, A. *Energy*, 2010, 35, (2), 1146–1156.

The design of the energy management is a basic problem in the preliminary design of complex buildings. The structure of the energy management is a set of main energy equipment, as well as relationships between them. For modern complex buildings the set of possible variants of the structure of energy management is numerous. The aim of preliminary design is the choice of the optimal variant of the energy management structure. The paper deals with the selection of the energy management structure of complex buildings. In order to achieve it, the algorithm of elaboration of the set of variants and the determination of the structure of the 'input–output' matrix has been developed. The paper contains the example of the determination of the binary 'input–output' matrix for an office building. For the selected variant of energy management the energy balance sheet has been completed.

10/02934 Multi-objective thermodynamic optimization of combined Brayton and inverse Brayton cycles using genetic algorithms

Besarati, S. M. *et al. Energy Conversion and Management*, 2010, 51, (1), 212–217.

This paper presents a simultaneous optimization study of two outputs performance of a previously proposed combined Brayton and inverse Brayton cycles. It has been carried out by varying the upper cycle pressure ratio, the expansion pressure of the bottom cycle and using variable, above atmospheric, bottom cycle inlet pressure. Multi-objective genetic algorithms are used for Pareto approach optimization of the cycle outputs. The two important conflicting thermodynamic objectives that have been considered in this work are net specific work (w_s) and thermal efficiency (ηth). It is shown that some interesting features among optimal objective functions and decision variables involved in the Baryton and inverse Brayton cycles can be discovered consequently.

10/02935 Numerical simulation of cloud rise phenomena associated with nuclear bursts

Kanarska, Y. *et al. Annals of Nuclear Energy*, 2009, 36, (10), 1475–1483.

This study presents numerical simulations of cloud evolution from nuclear explosions using high-resolution numerical methods. Early stages of nuclear explosions that are characterized by the blast wave propagation are simulated with an explicit code (GEODYN) that solves the compressible Navier–Stokes equations via a high-order Godunov scheme. As soon as the blast wave weakens ($\approx$10 s) the subsequent cloud rise due to buoyancy forces can be effectively simulated by the LMC code. LMC is an implicit code based on a pressure projection technique, and derived from the compressible Navier–Stokes equations using an asymptotic analysis in Mach number. It analytically eliminates time step restrictions based on sound wave propagation and it is computationally efficient and accurate for simulations of cloud rise dynamics at later stages. A series of cloud rise scenarios were performed ranging from an idealized bubble rise problem to realistic air bursts. The effects of compressible dynamics on cloud evolution at different stages were then analysed. It was found that in a realistic configuration, interaction of the reflected shock wave from the ground with the fireball significantly affects cloud evolution, in contrast to the equivalent idealized bubble rise simulations. The authors validated the code predictions against available experimental data. It was demonstrated that, by providing the initial source from the compressible GEODYN code, late time flow evolution can be successfully simulated with the fast, efficient and accurate LMC code.

10/02936 Reliability analysis of wind-excited structures

Pagnini, L. *Journal of Wind Engineering and Industrial Aerodynamics*, 2010, 98, (1), 1–9.

The structural effects induced by the wind constitute a stochastic process which depends, in turn, on the wind, the structure and the aerodynamic parameters. Structural verifications usually consider statistical moments of the process, such as the mean maximum or standard deviation, or its maximum value. Since the estimate of the parameters is uncertain, all these quantities should be treated as random. Therefore, the evaluation of the full distribution of the effect is often prohibitive to calculate. This paper studies the probabilistic response of wind-excited structures and carries out reliability analyses with respect to a limit state of a generalized wind load effect. When the effect considered is a deterministic quantity, the structural safety is studied applying, straightforward, simplified procedures. When the effect is a random variable, recourse is made to a suitable expression which separates the uncertainties due to the parameters of the calculation model and the inherent randomness of the wind load effect. In this way, an approximate description of the probability distribution of the response is given, suitable for reliability analyses. Neither the precision of the procedure, nor the numerical burden seems much affected by the number of random variables involved.

10/02937 Reliability and validity of risk analysis

Aven, T. and Heide, B. *Reliability Engineering & System Safety*, 2009, 94, (11), 1862–1868.

This study investigates the extent that risk analysis meets the scientific quality requirements of reliability and validity. The authors distinguish between two types of approaches within risk analysis, relative frequency-based approaches and Bayesian approaches. The former category includes both traditional statistical inference methods and the so-called probability of frequency approach. Depending on the risk analysis approach, the aim of the analysis is different, the results are presented in different ways and consequently the meaning of the concepts reliability and validity are not the same.

10/02938 Removal of ammonia nitrogen in wastewater by microwave radiation: a pilot-scale study

Lin, L. *et al. Journal of Hazardous Materials*, 2009, 168, (2–3), 862–867.

This study developed a continuous pilot-scale microwave (MW) system to remove ammonia nitrogen in real wastewater. A typical high concentration of ammonia nitrogen-contaminated wastewater, the coke-plant wastewater from a coke company, was treated. The output power of the microwave reactor was 4.8 kW and the handling capacity of the reactor was about 5 m^3 per day. The ammonia removal efficiencies under four operating conditions, including ambient temperature, wastewater flow rate, aeration conditions and initial concentration were evaluated in the pilot-scale experiments. The ammonia removal could reach about 80% for the real coke-plant wastewater with ammonia nitrogen concentrations of 2400–11,000 mg/L. The running cost of the MW technique was a little lower than the conventional steam-stripping method. The continuous microwave system showed the potential as an effective method for ammonia nitrogen removal in coke-plant water treatment. It is proposed that this process is suitable for the treatment of toxic wastewater containing high concentrations of ammonia nitrogen.

10/02939 The HEATSEP method for the synthesis of thermal systems: an application to the S-Graz cycle

Toffolo, A. *et al. Energy*, 2010, 35, (2), 976–981.

In the past decades component synthesis has become a critical issue in the research field of new highly integrated energy conversion systems. Several heuristic methodologies following experience-based guidelines have been proposed to simplify the problem of synthesis optimization. This paper describes an application of the HEATSEP method, which consists in the isolation of all the heat transfer processes of an energy system in an undefined 'black-box'. Then, synthesis optimization can be split in two subproblems, the first about the synthesis/design optimization of the basic plant configuration (which is made up of all the components but heat transfer devices) and the other about the synthesis of the heat exchanger network inside the black-box. The chosen test case is the design optimization of the basic plant configuration of an S-Graz cycle based power plant, as it is suitable to show the potentialities of the method.

10/02940 The physics of gas chimney and pockmark formation, with implications for assessment of seafloor hazards and gas sequestration

Cathles, L. M. *et al. Marine and Petroleum Geology*, 2010, 27, (1), 82–91.

Pockmarks form where fluids discharge through seafloor sediments rapidly enough to make them quick, and are common where gas is present in near-seafloor sediments. This paper investigates how gas might lead to pockmark formation. The process is as follows: a capillary seal traps gas beneath a fine-grained sediment layer or layers, perhaps layers whose pores have been reduced in size by hydrate crystallization. Gas accumulates until its pressure is sufficient for gas to invade the seal. The seal then fails completely (a unique aspect of capillary seals), releasing a large fraction of the accumulated gas into an upward-propagating gas chimney, which displaces water like a piston as it rises. Near the seafloor the water flow causes the sediments to become 'quick' (i.e. liquefied) in the sense that grain-to-grain contact is lost and the grains are suspended dynamically by the upward flow. The quickened sediment is removed by ocean-bottom currents, and a pockmark is formed. Equations that approximately describe this gas–piston–water-drive show that deformation of the sediments above the chimney and water flow fast enough to quicken the sediments begins when the gas chimney reaches half way from the base of its source gas pocket to the seafloor. For uniform near-surface sediment permeability, this is a buoyancy control, not a permeability control. The rate the gas chimney grows depends on sediment permeability and the ratio of the depth below seafloor of the top of the gas pocket to the thickness of the gas pocket at the time of seal failure. Plausible estimates of these parameters suggest gas chimneys at Blake Ridge could reach the seafloor in less than a decade or more than a century, depending mainly on the permeability of the deforming near-surface sediments. Since these become quick before gas is expelled, gas venting will not provide a useful warning of the seafloor instabilities that are related to pockmark formation. However, detecting gas chimney growth might be a useful risk predictor. Any area underlain by a gas chimney that extends half way or more to the surface should be avoided.

10/02941 Thermal radiation and the second law

Agudelo, A. and Cortés, C. *Energy*, 2010, 35, (2), 679–691.

The purpose of this paper is to collect and interrelate the fundamental concepts about second law analysis of thermal radiation. This heat transfer mode plays a leading role in solar energy utilization and in high-temperature devices, representing a significant contribution to irreversibility that is frequently omitted in engineering analysis. Entropy and exergy of thermal radiation are reviewed first. Radiative transfer processes are reviewed next, including exchange between surfaces, the presence of a participative medium, and the analysis of combined heat transfer modes. Emphasis is put on grey body radiation when treating with non-black body radiation, due to its relevance in engineering applications. The mathematical formulation of second law analysis of thermal radiation is complex, which limits its use in conventional heat transfer analysis. For this reason, numerical approaches reported to date deal with quite simple cases, leaving an open promising field of research.

10/02942 Thermodynamics of gases in nano cavities

Firat, C. *et al. Energy*, 2010, 35, (2), 814–819.

In nanoscale, gas density is not really homogenous even in thermodynamic equilibrium especially in a region near to the domain boundaries due to the wave character of gas particles. This inhomogeneous region is called quantum boundary layer (QBL) since its thickness goes to zero when the Planck's constant goes to zero. QBL can be neglected and density is assumed to be homogenous as long as thermal de Broglie wavelength (λ_T) of particles is negligible in comparison with the domain sizes. In nanoscale, however, this condition breaks down and QBL changes the thermodynamic behaviour of gases considerably. In literature, density distribution of a Maxwellian gas has been examined for only a rectangular domain to obtain the analytical results. In this study, density distribution is examined for some regular and irregular domain geometries for which the analytical solution is not possible. It is shown that QBL covers the whole surface of the domain and both thickness and density profile of QBL are independent of the domain geometry. It is concluded that

QBL has a universal thickness and density profile for a Maxwellian gas. Furthermore, an effective quantum potential is introduced to explain the inhomogeneous density distribution in thermodynamic equilibrium.

Fuel cell technology

10/02943 A multi-function compact fuel reforming reactor for fuel cell applications

Reed, J. *et al. Fuel*, 2010, 89, (5), 949–957.

A multi-function compact chemical reactor designed for hydrocarbon steam reforming was evaluated. The reactor design is based on diffusion bonded laminate micro-channel heat exchanger technology. The reactor consists of a combustor layer, which is sandwiched between two steam reforming layers. Between the two function layers, a temperature monitor and control layer is placed, which is designed to locate the temperature sensors. The combustor layer has four individually controlled combustion zones each connected to a separate fuel supply. The reactor design offers the potential to accurately control the temperature distribution along the length of the reactor using closed loop temperature control. The experimental results show that the variance of temperature along the reactor is negligible. The conversion efficiency of the combustor layer is approximately 90%. The heat transfer efficiency from combustion layer to reforming layers is 65–85% at 873 K and 673 K, respectively. The heat transfer rate to the reforming layers is sufficient to support a steam reformation of propane at a rate of 0.7 dm^3/min (STP) with a steam to carbon ratio of 2 at 873 K.

10/02944 A novel analytical analysis of PEM fuel cell

Yazdi, M. Z. *et al. Energy Conversion and Management*, 2010, 51, (2), 241–246.

In this study, a quasi three-dimensional model was developed for a single proton exchange membrane (PEM) fuel cell. The model was used for a half-cell which includes the cathode gas channel, gas diffusion layer (GDL), cathode catalyst layer and membrane is modelled. This model includes mass transfer in the gas channel and GDL, electrochemistry reaction in cathode catalyst layer, and charge transfer in the membrane phase. These expressions were solved by analytical methods. An agglomerate approach was used to describe cathode catalyst layer. By using analytical solution, the expressions can predict the PEM fuel cell behaviour in different conditions which is the advantage of this method.

10/02945 A novel bifunctional electrocatalyst for unitized regenerative fuel cell

Zhang, Y. *et al. Journal of Power Sources*, 2010, 195, (1), 142–145.

A novel bifunctional oxygen electrocatalyst for the unitized regenerative fuel cell (URFC) was prepared using 5 wt.% of platinum (Pt) nanoparticles highly dispersed on the surface of IrO_2 by chemical reduction. The catalyst was mixed with Pt black. The novel cell was evaluated in the hydrogen and oxygen fuel cell and water electrolysis modes, and compared to a similar cell with an oxygen electrode using conventional mixed Pt black and IrO_2 catalyst. With the novel oxygen electrode catalyst, the highest fuel cell power density was 1160 mW cm^{-2} at 2600 mA cm^{-2}; the overall performance was close to that with the commercial Pt supported on carbon catalyst and about 1.8 times higher than that with the conventional mixed Pt black and IrO_2 catalyst. Additionally, the cell performance for water electrolysis was also slightly improved, which was probably the result of lower interparticle catalyst resistance with 5 wt.% Pt on IrO_2 compared to no Pt on IrO_2.

10/02946 A review on fuel cell technologies and power electronic interface

Kirubakaran, A. *et al. Renewable and Sustainable Energy Reviews*, 2009, 13, (9), 2430–2440.

The issue of renewable energy is becoming significant due to increasing power demand, instability of the rising oil prices and environmental problems. Among the various renewable energy sources, fuel cell is gaining more popularity due to their higher efficiency, cleanliness and cost-effective supply of power demanded by the consumers. This paper presents a comprehensive review of different fuel cell technologies with their working principle, advantages, disadvantages and suitability of applications for residential/grid-connected system, transportation, industries and commercial applications. Development of mathematical model of fuel cell required for simulation study is discussed. This paper also focuses on the necessity of a suitable power-conditioning unit required to interface the fuel cell system with standalone/grid applications.

10/02947 Current density and polarization curves for radial flow field patterns applied to PEMFCs (proton exchange membrane fuel cells)

Cano-Andrade, S. *et al. Energy*, 2010, 35, (2), 920–927.

A numerical solution of the current density and velocity fields of a 3-D PEM radial configuration fuel cell is presented. The energy, momentum and electrochemical equations are solved using a computational fluid dynamics (CFD) code based on a finite volume scheme. There are three cases of principal interest for this radial model: four channels, eight channels and 12 channels placed in a symmetrical path over the flow field plate. The figures for the current–voltage curves for the three models proposed are presented, and the main factors that affect the behaviour of each of the curves are discussed. Velocity contours are presented for the three different models, showing how the fuel cell behaviour is affected by the velocity variations in the radial configuration. All these results are presented for the case of high relative humidity. The favourable results obtained for this unconventional geometry seems to indicate that this geometry could replace the conventional commercial geometries currently in use.

10/02948 Direct dimethyl-ether proton exchange membrane fuel cells and the use of heteropolyacids in the anode catalyst layer for enhanced dimethyl ether oxidation

Ferrell III, J. R. *et al. Journal of Power Sources*, 2010, 195, (1), 39–45.

In this study, polarization and impedance experiments were performed on a direct dimethyl ether fuel cell (DMEFC). The experimental setup allowed for independent control of water and DME flow rates. The DME flow rate, backpressure, and water flow rate were optimized. Three heteropolyacids, phosphomolybdic acid, $H_3PMo_{12}O_{40}$. (HPMo), phosphotungstic acid, $H_3PW_{12}O_{40}$, (HPW), and silicotungstic acid, $H_4SiW_{12}O_{40}$, (HSiW) were incorporated into the anode catalyst layer in combination with Pt/C. Both HPW-Pt and HSiW-Pt showed higher overall performance than the Pt control. Anodic polarizations were also performed, at 30 psig, Tafel slopes of 67 mV dec^{-1}, 72 mV dec^{-1}, and 79 mV dec^{-1} were found for HPW-Pt, HSiW-Pt and the Pt control, respectively. At 0 psig, the Tafel slopes were 56 mV dec^{-1}, 58 mV dec^{-1}, and 65 mV dec^{-1} for HPW-Pt, HSiW-Pt and the Pt control. The trends in the Tafel slope values are in agreement with the polarization data and the electrochemical impedance spectroscopy results. The addition of phosphotungstic acid more than doubled the power density of the fuel cell, compared to the Pt control. When the maximum power density obtained using the HPW-Pt MEA is normalized by the mass of Pt used, the optimal result, 78 mW mg^{-1} Pt, the highest observed at 30 psig and 100 °C to date.

10/02949 Effects of relative gas flow direction in the anode and cathode on the performance characteristics of a Molten Carbonate Fuel Cell

Kim, Y. J. *et al. Fuel*, 2010, 89, (5), 1019–1028.

In this work, three-dimensional numerical simulation of conservation equations for mass, momentum, energy, species and electrochemical reaction has been carried out to compare the performance characteristics of a molten carbonate fuel cell (MCFC) with three different flow types, co-flow, counter-flow and cross-flow. Depending on the flow types, distributions of pressure difference, temperature and current density in the electrolyte matrix were examined and the fractions of various losses were scrutinized. The simulation results show that the co-flow type has the lowest pressure difference across the matrix and the distributions of temperature and current density are more uniform than other types. However, it was found that since irreversible losses due to ohmic resistance, anode activation and cathode activation are smallest in the counter-flow type, best performance can be expected by the MCFC with the counter-flow type.

10/02950 Exergy analysis of PEM fuel cells for marine applications

Leo, T. J. *et al. Energy*, 2010, 35, (2), 1164–1171.

Fuel cells have a promising potential use in stationary and mobile power generation systems, as well as in automotive, aerospace or marine industries. At present, the main field of marine applications of fuel cells is submarines. Hydrogen/oxygen polymer electrolyte membrane (PEM) fuel cells are commonly used in this field. Storage of oxygen in liquid form is the optimal solution. Hydrogen can be stored in carbon-nanofibres or metallic hydrides, for example, or in liquid fuels, as alcohols, with further generation of the hydrogen required on-board. The objective of this study is to perform an exergetic analysis of two possibilities of using PEM fuel cells on surface ships and submarines: hydrogen/oxygen PEM fuel cells fed with hydrogen generated by reforming of methanol, and Direct Methanol Fuel Cells directly fed with liquid methanol. To do this, exergy losses and exergetic efficiencies are calculated for both configurations at selected optimal operation points.

10/02951 Fabrication of 80 mm diameter-sized solid oxide fuel cells using a water-based NiO–YSZ slurry

Hashimoto, N. *et al. Journal of the European Ceramic Society*, 2009, 29, (14), 3039–3043.

Solid oxide fuel cells (SOFCs) are very attractive for their high energy conversion efficiency and low emissions. Generally, a supported layer of SOFCs is fabricated by tape casting, using an organic solvent. Recently, a slurry based on water instead of an organic solvent has been sought in order to avoid environmental pollution. In this study, the anode of SOFCs was fabricated by aqueous tape casting, and the electrolyte and the cathode were deposited by screen printing. The I–V characteristics of the cell thus obtained were evaluated. As a result, an 80 mm diameter-sized cell with a power density of $0.33\ W/cm^2$ at 800 °C was successfully fabricated by controlling sintering conditions.

10/02952 Fuel cell systems and traditional technologies. Part II: experimental study on dynamic behavior of PEMFC in stationary power generation

Venturelli, L. *et al. Applied Thermal Engineering*, 2009, 29, (17–18), 3469–3475.

The present work is focused on electricity generation for stationary applications. The dynamic behaviour of a PEMFC-based system has been investigated at both constant and variable load conditions from an experimental point of view. An analysis of efficiency as a function of time has been proposed to summarize the dynamic performance; moreover, current intensity and voltage have been considered as main parameters of interest from the electric point of view. In addition, other energetic and thermodynamic parameters have been studied in this work. The experimental campaign has been carried out over four test typologies: constant load; increasing and decreasing load; random load. These tests have been planned to challenge the system with a variety of load-based cycles, in the frame of a thorough simulation of real-load conditions.

10/02953 Heat transfer in a PEMFC flow channel

Perng, S.-W. and Wu, H.-W. *Applied Thermal Engineering*, 2009, 29, (17–18), 3579–3594.

A numerical method was applied to the heat transfer performance in the flow channel for a proton exchange membrane fuel cell (PEMFC) using the finite element method (FEM). The heat transfer enhancement has been analysed by transversely installing a baffle plate and a rectangular cylinder to manage flow pattern in the flow channel of the fuel cell. Case studies include baffle plates (gap ratios from 00.05 to 0.2) and the rectangular cylinder (width-to-height ratios from 0.66 to 1.66 with a constant gap ratio of 0.2; various gap ratios from 0.05 to 0.3 with a constant width-to-height ratio 1.0) at constant Reynolds number. The results show that the transverse installation of a baffle plate and a rectangular cylinder in the flow channel can effectively enhance the local heat transfer performance of a PEMFC. The installation of a rectangular cylinder has a better effective heat transfer performance than a baffle plate; the larger the width of the cylinder is the better effective heat transfer performance becomes.

10/02954 PEM fuel cell model suitable for energy optimization purposes

Caux, S. *et al. Energy Conversion and Management*, 2010, 51, (2), 320–328.

Many fuel cell stack models or fuel cell system models exist. A model must be built with a main objective, sometimes for accurate electrochemical behaviour description, sometimes for optimization procedure at a system level. In this paper, based on the fundamental reactions present in a fuel cell stack, an accurate model and identification procedure is presented for future energy management in a hybrid electrical vehicle. The proposed approach extracts all important state variables in such a system and based on the control of the fuel cell's gas flows and temperature, simplification arises to a simple electrical model. Assumptions verified due to the control of the stack allow simplifying the relationships within keeping accuracy in the description of a global fuel cell stack behaviour from current demand to voltage. Modelled voltage and current dynamic behaviours are compared with actual measurements. The obtained accuracy is sufficient and less time-consuming (versus other previously published system-oriented models) leading to a suitable model for optimization iterative off-line algorithms.

10/02955 SOFC cogeneration system for building applications, part 1: development of SOFC system-level model and the parametric study

Lee, K. H. and Strand, R. K. *Renewable Energy*, 2009, 34, (12), 2831–2838.

A thermal and electrochemical model was developed for the simulation of a solid oxide fuel cell (SOFC) cogeneration system in this study. The modelling algorithms of electrochemical and thermal models were described. Since the fuel cell stack itself is only a single component within the whole SOFC system, the modelling of the balance-of-plant (BOP) components is also performed to assess the system-level performance. Using the new model, a parametric analysis was carried out to investigate the effects of fuel flow rate, extent of methane gas pre-reforming, fuel utilization factor, recycling rate of cathode gas and cell voltage on the overall system performance. As a result of the parametric study, fuel flow rate, cell voltage, fuel utilization and recycling rate of cathode gas turned out to improve system power output. In addition, the internal reforming was found to have an advantage over external reforming in terms of system power supply.

10/02956 SOFC cogeneration system for building applications, part 2: system configuration and operating condition design

Lee, K. H. and Strand, R. K. *Renewable Energy*, 2009, 34, (12), 2839–2846.

A solid oxide fuel cell (SOFC) cogeneration optimization study was carried out for one small-scale and one large-scale building under both hot and cold weather conditions. Several different configurations of the SOFC system are operated using a defined set of input parameters to meet the actual heating, cooling and electrical demands on those two buildings The results are discussed and compared from four different perspectives: electric-only vs cogeneration, energetic vs economic, large-scale vs small-scale buildings and hot vs cold weather conditions. The main conclusion of this study is that optimization results vary widely depending on different system configurations and loading conditions and thus SOFC systems should be optimized based on the specific conditions to which they are exposed and not simply on a single operating condition.

10/02957 Study of the effects of various parameters on the transient current density at polymer electrolyte membrane fuel cell start-up

Mishra, B. and Wu, J. *Renewable Energy*, 2009, 34, (10), 2296–2307.

An unsteady two-phase nonisothermal model is used to study the start-up characteristics of a polymer electrolyte membrane fuel cell (PEMFC). The model is 3D in nature and a PEMFC with serpentine flow field and nine channels is simulated. The base case is run with equilibrium or inflow initial conditions, i.e. the initial conditions inside the fuel cell are set to be equal to inflow conditions. The change in current density, at different potentials, with time is plotted. The effect of different parameters on the transient current density behaviour is studied. Single phase and two phase models are compared to understand the effect of liquid water on the performance at start-up and is seen to affect the current undershoot. Isothermal and nonisothermal models are also compared to see the effect of temperature. Following this, the gas diffusion layer thickness and the porosity are varied and are seen to have a significant effect on the current density. While both have an immediate effect on the mass transport time scales, the current density is affected by both transport and liquid water formation. The time scales of the above two mentioned phenomenon determine how the current behaves at start-up.

10/02958 The fading behavior of direct methanol fuel cells under a start-run-stop operation

Wongyao, N. *et al. Fuel*, 2010, 89, (5), 971–977.

Stability tests of direct methanol fuel cells (DMFCs) were conducted under two different operational modes, start-run-stop (SRS) and long-running (LR) modes, to investigate the difference in performance decay of the cells. Frequency response analysis (FRA), cyclic voltammetry (CV), transmission electron microscopy (TEM), X-ray diffraction (XRD) and energy dispersive X-ray spectroscopy (EDX) were used to identify the causes of cell degradation. The cell performance test results showed that the fading behaviour of the cell under the SRS operation was greater than that under the LR operation. The maximum power density was reduced approximately 20% and 32% of the initial value after operating under the LR and the SRS mode, respectively. This result was corresponded with the anode catalyst agglomeration data obtained from both XRD and TEM analysis. The increase of PtRu particle size under the SRS operation was higher than that under the LR operation. The FRA spectra showed that the anode reaction resistance increased from the initial value of $0.26\,\Sigma\,cm^2$ to $0.30\,\Sigma\,cm^2$ after life-testing under SRS mode for 45 h. A right-shift of the methanol oxidation peak and a 5.0% reduction of electrocatalyst surface area observed from the cyclic voltammograms also supported this finding. Finally the decay of cell performance was due to the Ru crossover, as verified by EDX results.

10/02959 Theoretical model with experimental validation of a regenerative blower for hydrogen recirculation in a PEM fuel cell system

Badami, M. and Mura, M. *Energy Conversion and Management*, 2010, 51, (3), 553–560.

A theoretical model of a regenerative blower used for the hydrogen recirculation of a proton exchange membrane (PEM) fuel cell for automotive applications has been implemented and validated by means of experimental data. A momentum exchange theory was used to determine the head-flow rate curves, whereas the circulatory flow rate was determined through a theory based on the consideration of the centrifugal force field in the side channel and in the impeller vane grooves. The model allows a good forecast to be made of the blower behaviour, and only needs its main geometrical characteristics and some fluid-dynamic data as input. For this reason, the model could be very interesting, especially during the first sizing and the design activity of the blower.

15 ENVIRONMENT

Pollution, health protection, applications

10/02960 A biogenic volatile organic compound emission inventory for Hong Kong

Tsui, J. K-Y. *et al. Atmospheric Environment*, 2009, 43, (40), 6442–6448.
Biogenic volatile organic compounds (BVOCs) in the atmosphere react to form ozone and secondary organic aerosols, which deteriorate air quality, affect human health, and indirectly influence global climate changes. The present study aims to provide a preliminary assessment of BVOC emissions in Hong Kong (HKSAR). Thirteen local tree species were measured for their isoprene emission potential. Tree distribution was estimated for country park areas based on field survey data. Plant emission data obtained from measurements and the literature, tree distribution estimation data, land use information, and meteorological data were combined to estimate annual BVOC emissions of 8.6×10^9 g C for Hong Kong. Isoprene, monoterpenes, and other VOCs contributed about 30%, 40%, and 30% of the estimated total annual emissions, respectively. Although hundreds of plant species are found in Hong Kong country parks, the model results indicate that only 10 tree species contribute about 76% of total annual VOC emissions. Prominent seasonal and diurnal variations in emissions were also predicted by the model. The present study lays a solid foundation for future local research, and results can be applied for studying BVOC emissions in nearby southern China and Asian regions that share similar climate and plant distributions.

10/02961 Addressing competitiveness and leakage concerns in climate policy: an analysis of border adjustment measures in the US and the EU

van Asselt, H. and Brewer, T. *Energy Policy*, 2010, 38, (1), 42–51.
The implementation of climate policies in the USA and European Union (EU) in light of uncertainties about future international climate policy has shifted attention to two interrelated concerns, namely competitiveness and carbon leakage. Although various policy measures are available to address these concerns, there has been much discussion about one such measure in particular: the use of offsetting measures at the border. This article compares policy discussions in the USA and the EU on how to address competitiveness and carbon leakage concerns, with a focus on the role of import-related border adjustment measures. It analyses the kinds of measures that so far have been put forward with a view to addressing competitiveness and carbon leakage; compares the approaches to the problems in the USA and the EU; and provides a preliminary discussion of international cooperation on border adjustment measures. It concludes that two kinds of cooperation are needed between the EU and the USA – not only cooperation through formal international negotiations, but also cooperation through international learning processes, in which the EU and the USA learn from each other about design and implementation issues as they develop their respective cap-and-trade systems.

10/02962 Biotoxicity evaluation of fly ash and bottom ash from different municipal solid waste incinerators

Chou, J. *et al. Journal of Hazardous Materials*, 2009, 168, (1), 197–202.
Different types of municipal solid waste incinerator (MSWI) fly and bottom ash were extracted by TCLP and PBET procedures. The biotoxicity of the leachate of fly ash and bottom ash was evaluated by *Vibrio fischeri* light inhibition test. The results indicate the following: (1) The optimal solid/liquid ratio was 1:100 for PBET extraction because it had the highest Pb and Cu extractable mass from MSWI fly ash. (2) The extractable metal mass from both fly ash and bottom ash by PBET procedure was significantly higher than that by TCLP procedure. (3) The metal concentrations of fly ash leachate from a fluidized bed incinerator was lower than that from mass-burning and mass-burning combined with rotary kiln incinerator. (4) The TCLP and PBET leachate from all MSWI fly ash samples showed biotoxicity. Even though bottom ash is regarded as a non-hazardous material, its TCLP and PBET leachate also showed biotoxicity. The pH significantly influenced the biotoxicity of leachate.

10/02963 Cardiovascular disease – risk benefits of clean fuel technology and policy: a statistical analysis

Gallagher, P. *et al. Energy Policy*, 2010, 38, (2), 1210–1222.
The hypothesis of this study is that there is a statistical relationship between the cardiovascular disease mortality rate and the intensity of fuel consumption (measured in gallons/square mile) at a particular location. The authors estimate cross-sectional regressions of the mortality rate due to cardiovascular disease against the intensity of fuel consumption using local data for the entire US, before the US Clean Air Act (CAA) in 1974 and after the most recent policy revisions in 2004. The cardiovascular disease rate improvement estimate suggests that up to 60 cardiovascular disease deaths per 100,000 residents are avoided in the largest urban areas with highest fuel consumption per square mile. In New York City, for instance, the mortality reduction may be worth about $30.3 billion annually. Across the US, the estimated value of statistical life (VSL) benefit is $202.7 billion annually. There are likely three inseparable reasons that contributed importantly to this welfare improvement. First, the CAA regulations banned leaded gasoline, and mandated reduction in specific chemicals and smog components. Second, technologies such as the catalytic converter for the automobile and the low particulate diesel engine were adopted. Third, biofuels have had important roles, making the adoption of clean air technology possible and substituting for high emission fuels.

10/02964 Characteristics of gaseous pollutants from biofuel-stoves in rural China

Wang, S. *et al. Atmospheric Environment*, 2009, 43, (27), 4148–4154.
The research team analysed the emission characteristics of gaseous pollutants, including volatile organic compounds (VOCs), from biomass combustion in improved stoves in rural China. The research included measurements from five biofuels and two stove types in the months of January, April, and September. The measurements were conducted according to US EPA Method 25 using a collection system with a cooling device and two-level filters. CO, CO_2, NO_x, CH_4 and THC analysers were used for in-field, real-time emission measurements. The emission data indicate that gaseous pollutants were emitted at higher concentrations in the early combustion stage and lower concentrations in the later stage. CH_4 and THC, as well as CO and CO_2, presented positive relationships during the whole entire combustion process for all tests. The chemical profiles of flue gas samples were analysed by GC/MS and GC/FID/ECD. Aromatics, carbonyls, and alkenes/alkynes dominated the VOC emissions, respectively accounting for 37%, 33%, and 23% of total VOC emissions by volume. Benzene was the most abundant VOC species, consisting of $17.3\pm8.1\%$ of VOCs, followed by propylene ($11.3\pm3.5\%$), acetone ($10.8\pm8.2\%$), toluene ($7.3\pm5.7\%$) and acetaldehyde ($6.5\pm7.3\%$). Carbon mass balance approach was applied to calculate CO, CO_2, CH_4, NO_x, and VOC species emission factors. This analysis includes a discussion of the differences among VOC emission factors of different biofuel-stove combinations.

10/02965 Characteristics of test and maintenance human errors leading to unplanned reactor trips in nuclear power plants

Kim, J. *et al. Nuclear Engineering and Design*, 2009, 239, (11), 2530–2536.
The test and maintenance (T&M) human errors involved in unplanned reactor trip events in Korean nuclear power plants were analysed according to James Reason's basic error types, and the characteristics of the T&M human errors by error type were delineated by the distinctive nature of major contributing factors, error modes, and the predictivity of possible errors. Human errors due to a planning failure where a work procedure is provided are dominated by the activities during low-power states or startup operations, and human errors due to a planning failure where a work procedure does not exist are dominated by corrective maintenance activities during full-power states. Human errors during execution of a planned work sequence show conspicuous error patterns; four error modes such as 'wrong object', 'omission', 'too little', and 'wrong action' appeared to be dominant. In view of a human error predictivity, human errors due to a planning failure is deemed to be very difficult to identify in advance, while human errors during execution are sufficiently predictable by using human error prediction or human reliability analysis methods with adequate resources.

10/02966 Demand for ISO 14001 adoption in the global supply chain: an empirical analysis focusing on environmentally conscious markets

Nishitani, K. *Resource and Energy Economics*, 2010, 32, (3), 395–407.

This paper analyses the environmental preferences and pressures of customers in environmentally conscious markets influencing the number of adoptions of ISO 14001 – the international standard certified by the International Organization for Standardization (ISO) concerning an environmental management system – in a country. Customers in different countries have different priorities and ideas with regard to the environment and its management, and therefore it is possible that environmental preferences and pressures of customers in environmentally conscious markets are greater, although many earlier studies suggest that foreign customers generally form a significant stakeholder group encouraging the adoption of ISO 14001. A random-effects Tobit estimation using a sample of 155 countries over eight years supports the view that the environmental preferences and pressures of customers in environmentally conscious markets (including Finland, Japan, Germany and Denmark) are more likely to encourage domestic along with foreign suppliers to adopt ISO 14001. As it is easier for firms in environmentally conscious markets to adopt ISO 14001 because of their better economic performance, they have already adopted certification and consequently require their domestic and foreign suppliers to do likewise in the global supply chain. For this reason, suppliers wishing to access environmentally conscious markets can obtain an advantage with ISO 14001 certification.

10/02967 Dynamic modelling of energy consumption, capital stock, and real income in G-7 countries

Lee, C.-C. and Chien, M.-S. *Energy Economics*, 2010, 32, (3), 564–581.

This paper applied an aggregate production function to examine the dynamic linkages among energy consumption, capital stock, and real income (real GDP per capita) in G-7 countries. The authors used a Granger causality test, the generalized impulse response approach, and variance decompositions in a multivariate setting to uncover the extent and the magnitude of the relationship among variables. The empirical results found evidence of a unidirectional relationship running from energy consumption to real income in Canada, Italy, and the UK, indicating that energy conservation may hinder economic growth in the three countries. Furthermore, the causality relationship appeared to be unidirectional, but reversed, for France and Japan, implying that energy conservation in both countries may still be viable, but without being detrimental to economic growth. As to Germany and the USA, there is no causality between the variables, which demonstrates the 'neutrality hypothesis', and in such a case economic growth will not affect energy use. The impact of capital stock was relatively higher compared with that of energy consumption. Transitory initial impacts of innovations in energy consumption on capital stock and real income were also observed.

10/02968 Energy consumption by gender in some European countries

Räty, R. and Carlsson-Kanyama, A. *Energy Policy*, 2010, 38, (1), 646–649.

Household total energy use has been estimated in numerous studies in recent decades and differences have mainly been explained by levels of income/expenditure. Studies of gender consumption patterns show that men eat more meat than women and drive longer distances, potentially leading to higher total energy use by men. This study calculated the total energy use for male and female consumption patterns in four European countries (Germany, Norway, Greece and Sweden) by studying single households. Significant differences in total energy use were found in two countries, Greece and Sweden. The largest differences found between men and women were for travel and eating out, alcohol and tobacco, where men used much more energy than women. It is suggested that these findings are policy relevant for the EU, which aims to mainstream gender issues into all activities and to lower its total energy use.

10/02969 Environmental costs of a river watershed within the European water framework directive: results from physical hydronomics

Martínez, A. *et al. Energy*, 2010, 35, (2), 1008–1016.

Physical hydronomics (PH) is the specific application of thermodynamics that physically characterizes the governance of water bodies, i.e. the Water Framework Directive (WFD) for European Union citizens. In this paper, calculation procedures for the exergy analysis of river basins are developed within the WFD guidelines and a case study is developed. Therefore, it serves as an example for the feasible application of PH in the environmental cost assessment of water bodies, accordingly to the principle of recovery of the costs related to water services in accordance with the polluter pays principle, one of the milestones of the WFD. The Foix River watershed, a small river located at the Inland Basins of Catalonia, has been analysed. Main results, difficulties, and constraints encountered are shown in the paper. Following WFD's quantity and quality objectives previously defined, water costs are calculated and the equivalence between the exergy loss due to water users and the exergy variation along the river are also analysed.

10/02970 Evaluating and ranking energy performance of office buildings using fuzzy measure and fuzzy integral

Lee, W.-S. *Energy Conversion and Management*, 2010, 51, (1), 197–203.

Traditional methods of evaluating energy performance of building tend to focus on comparing the observed energy consumption with the average value of energy consumption by regression method or theoretical value calculated by simulation analysis. This paper attempted to evaluate and rank the energy performance of buildings from the perspective of multiple objective outputs. Specifically, considering the interactions between the weights of attributes of building energy performance, this paper adopts fuzzy measure and fuzzy integral, one of the multiple attribute decision-making approaches, to rank the evaluated buildings. The energy performance of 47 office buildings in Taiwan were evaluated and ranked to serve as a case study to illustrate the procedure and effectiveness of the proposed approach.

10/02971 Evaluation of major polluting accidents in China – results and perspectives

Hou, Y. and Zhang, T. *Journal of Hazardous Materials*, 2009, 168, (2–3), 670–673.

Lessons learnt from accidents are essential sources for updating state-of-the-art requirements in pollution accident prevention. To improve this input in the People's Republic of China in a systematic way, a database for collecting and evaluating major pollution accidents is being established. This is being done in co-operation with Chinese Society for Environment Sciences and other national Institutions. At the time of writing over 80 major events from 2002–2006 have been collected. In this paper, a summary evaluation on the major polluting events in China from 2002 to 2006 is presented and some basic lessons drawn shown. There is no a systematic pollution accident notification system currently in China. The results from root cause analysis underline the importance of emergency measures, maintenance, human factor issues and the role of safety organization. Chronic pollution, especially water pollution and air pollution should be paid the same attention as the sudden pollution. It is important to keep in mind that collecting information from major accidents represents a small percentage of the actual number of events taking place.

10/02972 Exposure to ultrafine and fine particles and noise during cycling and driving in 11 Dutch cities

Boogaard, H. *et al. Atmospheric Environment*, 2009, 43, (27), 4234–4242.

Recent studies have suggested that exposures during traffic participation may be associated with adverse health effects. Traffic participation involves relatively short but high exposures. Potentially relevant exposures include ultrafine particles, fine particles ($PM_{2.5}$) and noise. Simultaneously, detailed real time exposure of particle number concentration (PNC), $PM_{2.5}$ and noise has been measured while driving and cycling 12 predefined routes of approximately 10–20 min duration. Sampling took place in eleven medium-sized Dutch cities on eleven weekdays in August till October 2006. To investigate variability in cyclists exposure, the authors systematically collected information on meteorology, GPS coordinates, type of road, traffic intensity, passing vehicles and mopeds while cycling. The overall mean PNC of car drivers was 5% higher than the mean PNC of cyclists. The overall mean concentration of $PM_{2.5}$ in the car was 11% higher than during cycling. Slightly higher 1-min peak concentrations were measured in the car (PNC 14%; $PM_{2.5}$ 29% for 95-percentiles). Shorter duration peaks of PNC were higher during cycling (43% for 99-percentile of 1-s averages). Peaks in PNC typically last for less than 10 s. A large variability of exposure was found within and between routes. Factors that significantly predicted PNC variability during cycling were: passing vehicles (mopeds, cars), waiting for traffic lights, passing different types of (large) intersections and bicycle lanes and bike paths close to motorized traffic. No relation was found between $PM_{2.5}$ and those predictor variables. The correlation between PNC and noise was moderate (median 0.34). $PM_{2.5}$ had very low correlations with PNC and noise. PNC and $PM_{2.5}$ exposure of car drivers was slightly higher than that of cyclists. PNC was largely uncorrelated with $PM_{2.5}$ and reflected local traffic variables more than $PM_{2.5}$. Different factors were associated with high PNC and high noise exposures.

10/02973 Factor analysis on hazards for safety assessment in decommissioning workplace of nuclear facilities using a semantic differential method

Jeong, K.-S. and Lim, H.-K. *Annals of Nuclear Energy*, 2009, 36, (10), 1639–1647.

The decommissioning of nuclear facilities must be accomplished according to its structural conditions and radiological characteristics. An effective risk analysis requires basic knowledge about possible risks, characteristics of potential hazards, and comprehensive understanding of the associated cause-effect relationships within a decommissioning for nuclear facilities. The hazards associated with a decommissioning plan are important not only because they may be a direct cause of harm to workers but also because their occurrence may, indirectly, result in increased radiological and non-radiological hazards. Workers need to be protected by eliminating or reducing the radiological and non-radiological hazards that may arise during routine decommissioning activities as well as during accidents. Therefore, to prepare the safety assessment for decommissioning of nuclear facilities, the radiological and non-radiological hazards should be systematically identified and classified. With a semantic differential method of screening factor and risk perception factor, the radiological and non-radiological hazards are screened and identified.

10/02974 Housing, energy cost, and the poor: counteracting effects in Germany's housing allowance program

Grösche, P. *Energy Policy*, 2010, 38, (1), 93–98.

Adequate housing and affordable warmth are essential human needs, the lack of which may seriously harm people's health. Germany provides an allowance to low-income households, covering the housing as well as the space heating cost, to protect people from the consequences of poor housing conditions and fuel poverty. In order to limit public expenditures, payment recipients are required to choose low-cost dwellings, with the consequence that they probably occupy flats with a poor thermal performance. Recipients might therefore exhibit a lower per-square metre rent but in turn are likely to have a higher energy consumption and energy expenditures. Using a large data set of German households, this paper demonstrates that this financially counteracting effect is of negligible magnitude.

10/02975 Income, resources, and electricity mix

Burke, P. J. *Energy Economics*, 2010, 32, (3), 616–626.

This paper presents evidence on a national-level electricity ladder, which sees the transition of countries towards coal and natural gas, and finally nuclear power and modern renewables such as wind power, for their electricity needs as they develop. The extent to which countries climb the electricity ladder is dependent on energy endowments. The results imply that the environmental implications of economic development differ in countries with different energy resource endowments. An effective global carbon mitigation strategy will require developing countries to leapfrog the middle rungs of the electricity ladder.

10/02976 Input-profile-based software failure probability quantification for safety signal generation systems

Kang, H. G. *et al. Reliability Engineering & System Safety*, 2009, 94, (10), 1542–1546.

The approaches for software failure probability estimation are mainly based on the results of testing. Test cases represent the inputs, which are encountered in an actual use. The test inputs for the safety-critical application such as a reactor protection system (RPS) of a nuclear power plant are the inputs which cause the activation of protective action such as a reactor trip. A digital system treats inputs from instrumentation sensors as discrete digital values by using an analogue-to-digital converter. Input profile must be determined in consideration of these characteristics for effective software failure probability quantification. Another important characteristic of software testing is that there is no need to repeat the test for the same input value since the software response is deterministic for each specific digital input. With these considerations, the authors propose an effective software testing method for quantifying the failure probability. As an example application, the input profile of the digital RPS is developed based on the typical plant data. The proposed method in this study is expected to provide a simple but realistic mean to quantify the software failure probability based on input profile and system dynamics.

10/02977 Introduction of subsidisation in nascent climate-friendly learning technologies and evaluation of its effectiveness

Rout, U. K. *et al. Energy Policy*, 2010, 38, (1), 520–532.

Given its importance as a practical phenomenon underlying the progress of learning technologies, attention should be paid to the role of subsidization in learning theory, particularly in the case of nascent climate-related sociable learning technologies, in order to examine its benefits. Thus, this study focuses on subsidy procurement of energy technologies in several economies in the context of the component learning track in endogenous global clusters in order to suggest improvements to the adoption mechanism and examine the climate stabilization constraint. At the same time, the study attempts to determine the global progress ratio of the lithium-ion battery in order to analyse various endogenous learning scenarios for hybrid technologies. An integrated energy system model with highly disaggregated global regions (DNE21+) is used to execute this research in a medium time frame. Subsidization of the learning track of battery technology encourages greater development of plug-in hybrid vehicles, promotes early diffusion of hybrid technologies, and relieves heavy dependency on crude oil and biofuels. The subsidies in the common learning domains in few economies benefit the nearby economies because of the technology spillover that occurs through numerous cross-feedback learning mechanisms. Endogenous learning with subsidies augments diffusion potentials, abates emissions, and shifts sectoral emissions.

10/02978 Inventory of the exergy resources on earth including its mineral capital

Valero, A. *et al. Energy*, 2010, 35, (2), 989–995.

This paper makes an inventory of the natural capital on earth in terms of exergy, which includes not only renewable and non-renewable energy resources, but also non-fuel minerals. The exergy method is very suitable for the accounting of natural capital because all kinds of resources can be assessed with a single property. For the case of minerals, exergy allows to unify properties tonnage and grade. Furthermore, the exergy replacement costs of minerals includes additional information of the state of technology. The aggregation capacity of the exergy and exergy replacement cost indicators increases the analysis potential of the results. This way, the non-fuel mineral's wealth can be compared to that of fuel minerals or even to other natural resources. The results of this study reveal that the real scarcity problems that humankind are facing are not based on the lack of energy sources, but on the lack of minerals.

10/02979 Nuclear plant's virtual simulation for on-line radioactive environment monitoring and dose assessment for personnel

Mól, A. C. A. *et al. Annals of Nuclear Energy*, 2009, 36, (11–12), 1653–1662.

This paper reports the use of nuclear plant's simulation for online dose rate monitoring and dose assessment for personnel, using virtual reality technology. The platform used for virtual simulation was adapted from a low-cost game engine, taking advantage of all its image rendering capabilities, as well as the physics for movement and collision, and networking capabilities for multi-user interactive navigation. A real nuclear plant was virtually modelled and simulated, so that a number of users can navigate simultaneously in this virtual environment in first or third person view, each one receiving visual information about both the radiation dose rate in each actual position, and the radiation dose received. Currently, this research and development activity has been extended to consider also on-line measurements collected from radiation monitors installed in the real plant that feed the simulation platform with dose rate data, through a TCP/IP network. Results are shown and commented, and other improvements are discussed, as the execution of a more detailed dose rate mapping campaign.

10/02980 Occupants' adaptive responses and perception of thermal environment in naturally conditioned university classrooms

Yao, R. *et al. Applied Energy*, 2010, 87, (3), 1015–1022.

A year-long field study of the thermal environment in university classrooms was conducted from March 2005 to May 2006 in Chongqing, China. This paper presents the occupants' thermal sensation votes and discusses the occupants' adaptive response and perception of the thermal environment in a naturally conditioned space. Comparisons between the actual mean vote and predicted mean vote have been made as well as between the actual percentage of dissatisfied and predicted percentage of dissatisfied. The adaptive thermal comfort zone for the naturally conditioned space for Chongqing, which has hot summer and cold winter climatic characteristics, has been proposed based on the field study results. The Chongqing adaptive comfort range is broader than that of the ASHRAE Standard 55–2004 in general, but in the extreme cold and hot months, it is narrower. The thermal conditions in classrooms in Chongqing in summer and winter are severe. Behavioural adaptation such as changing clothing, adjusting indoor air velocity, taking hot/cold drinks, etc., as well as psychological adaptation, has played a role in adapting to the thermal environment.

10/02981 Organic carbon, total nitrogen, and water-soluble ions in clouds from a tropical montane cloud forest in Puerto Rico

Reyes-Rodríguez, G. J. *et al. Atmospheric Environment*, 2009, 43, (27), 4171–4177.

Chemical characterization to determine the organic and nitrogen fractions was performed on cloud water samples collected in a mountain-top site in Puerto Rico. The cloud water samples showed average concentrations of $1.09\,\mathrm{mg\,L^{-1}}$ of total organic carbon (TOC), of $0.85\,\mathrm{mg\,L^{-1}}$ for dissolved organic carbon (DOC) and of and $1.25\,\mathrm{mg\,L^{-1}}$ for total nitrogen (TN). Concentrations of organic nitrogen

(ON) changed with the origin of the air mass. Changes in their concentrations were observed during periods under the influence of African dust (AD). The ON/TN ratios were 0.26 for the clean and 0.35 for the AD periods. Average concentrations of all these species were similar to those found in remote environments with no anthropogenic contribution. In the AD period, for cloud water the concentrations of TOC were four times higher and TN were three times higher than during periods of clean air masses associated with the trade winds. These results suggest that a significant fraction of TOC and TN in cloud and rainwater is associated to airborne particulate matter present in dust. Functional groups were identified using proton nuclear magnetic resonance (^1H NMR) spectroscopy. This characterization led to the conclusion that water-soluble organic compounds in these samples are mainly aliphatic oxygenated compounds, with a small amount of aromatics. The ion chromatography results showed that the ionic species were predominantly of marine origin, for air masses with and without African dust influence, with cloud water concentrations of NO_3^- and NH_4^+ much lower than from polluted areas in the US. An increase of such species as SO_4^{2-}, Cl^-, Mg^{2+}, K^+ and Ca^{2+} was seen when air masses originated from northwest Africa. The changes in the chemical composition and physical properties of clouds associated with these different types of aerosol particles could affect on cloud formation and processes.

10/02982 Putting renewables and energy efficiency to work: how many jobs can the clean energy industry generate in the US?

Wei, M. *et al. Energy Policy*, 2010, 38, (2), 919–931.

An analytical job creation model for the US power sector from 2009 to 2030 is presented. The model synthesizes data from 15 job studies covering renewable energy (RE), energy efficiency (EE), carbon capture and storage (CCS) and nuclear power. The paper employs a consistent methodology of normalizing job data to average employment per unit energy produced over plant lifetime. Job losses in the coal and natural gas industry are modelled to project net employment impacts. Benefits and drawbacks of the methodology are assessed and the resulting model is used for job projections under various renewable portfolio standards (RPS), EE, and low carbon energy scenarios. All non-fossil fuel technologies (renewable energy, EE, low carbon) were found to create more jobs per unit energy than coal and natural gas. Aggressive EE measures combined with a 30% RPS target in 2030 can generate over 4 million full-time-equivalent job-years by 2030 while increasing nuclear power to 25% and CCS to 10% of overall generation in 2030 can yield an additional 500,000 job-years.

10/02983 Safety climate: leading or lagging indicator of safety outcomes?

Payne, S. C. *et al. Journal of Loss Prevention in the Process Industries*, 2009, 22, (6), 735–739.

This paper theorizes how and why safety climate can be conceived as both a leading and a lagging indicator of safety events (i.e. accidents, injuries). When safety climate is conceived as a leading indicator, a prospective design is utilized and safety climate data are correlated with accidents/injuries that occur in the future. When safety climate is conceived as a lagging indicator, retrospective designs are used in which safety climate data are correlated with prior accidents/injuries. The authors examine the research literature to reveal that safety climate has been investigated as both a leading and a lagging indicator, but it is usually only examined as one or the other within a given study and has been examined as a lagging indicator most frequently. Consistent with the authors' theories, prospective designs yield stronger relationships than retrospective designs, suggesting that safety climate is a better leading indicator than lagging indicator; however, it is clearly both. Implications for safety climate research and study design are discussed.

10/02984 Street canyon ventilation and atmospheric turbulence

Salizzoni, P. *et al. Atmospheric Environment*, 2009, 43, (32), 5056–5067.

Operational models for pollutant dispersion in urban areas require an estimate of the turbulent transfer between the street canyons and the overlying atmospheric flow. To date, the mechanisms that govern this process remain poorly understood. The authors have studied the mass exchange between a street canyon and the atmospheric flow above it by means of wind tunnel experiments. Fluid velocities were measured with a particle image velocimetry system and passive scalar concentrations were measured using a flame ionization detector. The mass-transfer velocity between the canyon and the external flow has been estimated by measuring the cavity wash-out time. A two-box model, used to estimate the transfer velocity for varying dynamical conditions of the external flow, has been used to interpret the experimental data. This study sheds new light on the mechanisms which drive the ventilation of a street canyon and illustrates the influence of the external turbulence on the transfer process.

10/02985 Technology transfers and the clean development mechanism in a North–South general equilibrium model

Aronsson, T. *et al. Resource and Energy Economics*, 2010, 32, (3), 292–309.

This paper analyses the potential welfare gains of introducing a technology transfer from Annex I to non-Annex I in order to mitigate greenhouse gas emissions. This analysis is based on a numerical general equilibrium model for a world-economy comprising two regions; north (Annex I) and south (non-Annex I). In a cooperative equilibrium, a technology transfer from the north to the south is clearly desirable from the perspective of a 'global social planner', since the welfare gain for the south outweighs the welfare loss for the north. However, if the regions do not cooperate, then the incentives to introduce the technology transfer appear to be relatively weak from the perspective of the north; at least if southern abatement is allowed for in the pre-transfer Nash equilibrium. Finally, by adding the emission reductions associated with the Kyoto agreement, the results show that the technology transfer leads to higher welfare in both regions.

10/02986 The assessment of health damage caused by air pollution and its implication for policy making in Taiyuan, Shanxi, China

Zhang, D. *et al. Energy Policy*, 2010, 38, (1), 491–502.

This study establishes the link between energy use, air pollution, and public health impacts in Taiyuan for 2000, and for 2010 and 2015 under alternative scenarios. In 2000 more than 2200 excess deaths may have been caused by particulate matter (PM) pollution. Using alternative methods for monetization of health impacts the total health damage amounts to 0.8–1.7 billion Yuan, which is 2.4–4.9% of the city's GDP in 2000. Compared to the business-as-usual scenario, scenarios assuming extensive fuel switch in low-and-medium-stack pollution sources and extension of the district heating system could prevent 200–1100 PM_{10}-related premature deaths in 2010 and substantially reduce population morbidity. The actual PM pollution in 2007 was lower than modelled in these two scenarios. It was also found that if air quality in urban Taiyuan were to reach the Chinese National Grade II Standard in 2015, the number of premature deaths would still be around 1330 and the economic cost about 1–2% of the city's GDP in 2015. The results imply that there are large health benefits to be gained by setting stricter standards for the future in China, and that targeting low-and-medium-stack source effectively reduces health damage.

10/02987 The environmental Kuznets curve hypothesis for water pollution: do regions matter?

Lee, C.-C. *et al. Energy Policy*, 2010, 38, (1), 12–23.

This study revisits the environmental Kuznets curve (EKC) hypothesis for water pollution by using a recent dynamic technique, which is the generalized method of moments (GMM) approach, for a board sample of 97 countries during the period 1980–2001. On a global scale, as the EKC relationship cannot be obtained between real income and biological oxygen demand emissions, this paper further classifies these countries into four regional groups – Africa, Asia and Oceania, America, and Europe – to explore whether the different regions have different EKC relationships. The empirical results show evidence of the inverted U-shaped EKC relationships' existence in America and Europe, but not in Africa and Asia and Oceania. Thus, the regional difference of EKC for water pollution is supported. Furthermore, the estimated turning points are, approximately, US$13,956 and $38,221 for America and Europe, respectively.

CO_2, NO_x, SO_2 and particulate emissions

10/02988 A numerical experiment of roadside diffusion under traffic-produced flow and turbulence

Kondo, H. and Tomizuka, T. *Atmospheric Environment*, 2009, 43, (27), 4137–4147.

Roadside air pollution due to heavy traffic is one of the unsettled issues in the atmospheric environment in urban areas. As a practical application of a computational fluid dynamics (CFD) model, a coupled mesoscale-CFD model was applied to the Ikegamicho area of Kawasaki City, Japan. For this study, the effects of traffic-produced flow and turbulence (TPFT) on the dispersion of the pollutants near the heavy traffic road were mainly investigated in an actual urban area. First, a series of preliminary CFD calculations was conducted for a road tunnel field experiment to obtain a fitting parameter for the traffic-produced flow. The calculation was then performed for 24 h in December 2005 around Ikegamicho, and the results were compared with the data at a roadside monitoring post in the area, located 10 m from the boundary of the ground road. In general, the effect of traffic-produced flow and turbulence was limited at the downstream side of the roads. The maximum concentration of NO_x was reduced and smoothed out along the traffic flow by the traffic-produced flow and turbulence on the road. The effects of traffic-produced turbulence on the dispersion of pollutants were greater than those of traffic-produced flow; however, the effects of traffic-produced flow were not negligible. The concentration of pollutants was not particularly dependent on the turbulent Schmidt number because most of the emission sources were introduced as volume sources in the present calculations, and the effect caused by differences in the material diffusion coefficient was not particularly significant at the outside of the road.

10/02989 A roadmap for carbon capture and storage in the UK

Gough, C. *et al. International Journal of Greenhouse Gas Control*, 2010, 4, (1), 1–12.

Carbon capture and storage (CCS) technology has been endorsed by the IPCC and the UK government as a key mitigation option but remains on the cusp of wide-scale commercial deployment. A technology roadmap for CCS is presented here, depicted in terms of external factors and short- and long-term pathways for its development, moving from a demonstration to commercialization era. The roadmap was developed through a two-phase process of stakeholder engagement; the second phase of this, a high-level stakeholder workshop, is documented here. This approach has provided a unique overview of the current status, potential and barriers to CCS deployment in the UK. In addition to the roadmap graphics and more detailed review, five consensus conclusions emerging from the workshop are presented. These describe the need for a monetary CO_2 value and the financing of carbon capture and storage schemes; the lack of technical barriers to the deployment of demonstration scale CCS plant; the role of demonstration projects in developing a robust regulatory framework; key storage issues; the need for a long-term vision in furthering both the technical and non-technical development of CCS.

10/02990 A two-stage inexact-stochastic programming model for planning carbon dioxide emission trading under uncertainty

Chen, W. T. *et al. Applied Energy*, 2010, 87, (3), 1033–1047.

In this study, a two-stage inexact-stochastic programming (TISP) method is developed for planning carbon dioxide (CO_2) emission trading under uncertainty. The developed TISP incorporates techniques of interval-parameter programming and two-stage stochastic programming within a general optimization framework. The TISP can not only tackle uncertainties expressed as probabilistic distributions and discrete intervals, but also provide an effective linkage between the pre-regulated greenhouse gas (GHG) management policies and the associated economic implications. The developed method is applied to a case study of energy systems and CO_2 emission trading planning under uncertainty. The results indicate that reasonable solutions have been generated. They can be used for generating decision alternatives and thus help decision makers identify desired GHG abatement policies under various economic and system-reliability constraints.

10/02991 Characterization of $PM_{2.5}$-bound polycyclic aromatic hydrocarbons in Atlanta – seasonal variations at urban, suburban, and rural ambient air monitoring sites

Li, Z. *et al. Atmospheric Environment*, 2009, 43, (27), 4187–4193.

Twenty-eight polycyclic aromatic hydrocarbons (PAH) and methylated PAHs (Me-PAH) were measured in daily $PM_{2.5}$ samples collected at an urban site, a suburban site, and a rural site in and near Atlanta during 2004 (5 samples/month/site). The suburban site, located near a major highway, had higher $PM_{2.5}$-bound PAH concentrations than did the urban site, and the rural site had the lowest PAH levels. Monthly variations are described for concentrations of total PAHs (ΣPAHs) and individual PAHs. PAH concentrations were much higher in cold months than in warm months, with average monthly ΣPAH concentrations at the urban and suburban-highway monitoring sites ranging from 2.12 to 6.85 $ng\,m^{-3}$ during January–February and November–December 2004, compared to 0.38–0.98 $ng\,m^{-3}$ during May–September 2004. ΣPAH concentrations were found to be well correlated with $PM_{2.5}$ and organic carbon (OC) within seasons, and the fractions of PAHs in $PM_{2.5}$ and OC were higher in winter than in summer. Methyl phenanthrenes were present at higher levels than their un-substituted homologue (phenanthrene), suggesting a petrogenic (unburned petroleum products) input. Retene, a proposed tracer for biomass burning, peaked in March, the month with the highest acreage and frequency of prescribed burning and unplanned fires, and in December, during the high residential wood-burning season, indicating that retene might be a good marker for burning of all biomass materials. In contrast, potassium peaked only in December, indicating that it might be a more specific tracer for wood-burning.

10/02992 Charge-to-mass ratio and dendrite structure of diesel particulate matter charged by corona discharge

Kuroki, T. *et al. Carbon*, 2010, 48, (1), 184–190.

The electric charge of diesel particulate matter (DPM) from a corona discharge device is measured for understanding the electrical characteristics of the DPM; an electrostatic precipitator (ESP) is employed for trapping DPM. Exhaust gas from a diesel engine is sampled by isokinetic sampling, and DPM contained in the gas is charged by negative corona discharge. The charged DPM is collected by a Faraday cup, and its electric charge is measured by a Coulomb metre. In addition, the appearance of the collected DPM is observed using a scanning electron microscope. It is found that when the gas velocity is 0.28 m/s, the maximum charge-to-mass ratio of the DPM is $-126\,\mu C/g$. The DPM appears to agglomerate into a large particle in the absence of corona discharge; however, the agglomerated DPM forms a dendrite structure in the presence of corona discharge. The dendrite structure causes an increase in the surface area of the agglomerated DPM. Therefore, the oxidation removal of the DPM trapped by the ESP by using ozone and nitrogen dioxide can be enhanced because an oxidation reaction occurs on the surface of the DPM.

10/02993 Combining deterministic and statistical approaches for PM_{10} forecasting in Europe

Konovalov, I. B. *et al. Atmospheric Environment*, 2009, 43, (40), 6425–6434.

Well-documented adverse health effects of airborne particulate matter (PM) stimulate intensive research aimed at understanding and forecasting its behaviour. Forecasting of PM levels is commonly performed with either statistical or deterministic chemistry-transport models (CTM). This study investigates the advantages of combining deterministic and statistical approaches for PM_{10} forecasting over Europe one day ahead. The proposed procedure involves statistical postprocessing of deterministic forecasts by using PM_{10} monitoring data. A series of experiments is performed using a state-of-the-art CTM (CHIMERE) and statistical models based on linear regressions. It is found that performance of both CTM simulations and 'pure' statistical models is inferior to that of the combined models. In particular, the root mean squared error of the deterministic forecasts can be reduced, on the average, by up to 45% (specifically, from 12.8 to 6.9 $\mu g/m^3$ at urban sites in summer) and the coefficient of determination can be almost doubled. Importantly, it is found that the combined models for rural sites in summer and for urban and suburban sites in both summer and winter are representative, on the average, not only for a given monitoring site used for their training, but also of territories of similar type of environment (rural, suburban or urban) within several hundreds of kilometres away.

10/02994 Comparative study of chemical absorbents in postcombustion CO_2 capture

Pellegrini, G. *et al. Energy*, 2010, 35, (2), 851–857.

In order to reduce CO_2 emissions from a power plant, CO_2 can be captured either from the syngas that is to be burned or from the flue gases exiting the energy conversion process. Postcombustion capture has the advantage that it can be applied to retrofit existing power plants. In this paper the authors compare two primary amines (MEA and DGA) to ammonia with respect to their capability to capture CO_2 from a flue gas stream. The ammonia process captures CO_2 by formation of stable salts, which are separated from the solvent stream by filtration or sedimentation. These salts can be used commercially as fertilizers. Energy requirements are greatly reduced, since no heat is required for solvent regeneration, and no compression of the separated CO_2 is necessary. Energy, however, is required for the reduction of ammonia emissions. In order to obtain the solid ammonia salts, their solubility has to be reduced by modification of the solvent and by lowering absorption temperature. With and without separation of the salt products, ammonia proved to be an alternative solvent with high CO_2 removal efficiency. Simulation of all processes was carried out with Aspen Plus® and compared to experimental results for CO_2 scrubbing with ammonia.

10/02995 Computational intelligence approach for NO_x emissions minimization in a coal-fired utility boiler

Zhou, H. *et al. Energy Conversion and Management*, 2010, 51, (3), 580–586.

The current work presented a computational intelligence approach used for minimizing NO_x emissions in a 300 MW dual-furnaces coal-fired utility boiler. The fundamental idea behind this work included NO_x emissions characteristics modelling and NO_x emissions optimization. First, an objective function aiming at estimating NO_x emissions characteristics from nineteen operating parameters of the studied boiler was represented by a support vector regression (SVR) model. Second, four levels of primary air velocities (PA) and six levels of secondary air velocities (SA) were regulated by using particle swarm optimization (PSO) so as to achieve low NO_x emissions combustion. To reduce the time demanding, a more flexible stopping condition was used to improve the computational efficiency without the loss of the quality of the optimization results. The results showed that the proposed approach provided an effective way to reduce NO_x emissions from 399.7 ppm to 269.3 ppm, which was much better than a genetic algorithm (GA) based method and was slightly better than an ant colony optimization (ACO) based approach reported in the earlier work. The main advantage of PSO was that the computational cost, typical of less than 25 s under a PC system, is much less than those required for ACO. This meant the proposed approach would be more applicable to online and real-time applications for NO_x emissions minimization in actual power plant boilers.

10/02996 Effects of gas temperature fluctuation on the NO release from pulverized coal particle during char combustion

Zhang, H. and Zhang, J. *Fuel*, 2010, 89, (5), 1177–1180.

The effects of gas temperature fluctuation on the NO release from pulverized coal particle during char combustion are investigated. The computed results show that the NO formation through the heterogeneous oxidation and reduction reactions is influenced by the gas temperature fluctuation for the particles with initial diameters of 10–50 μm. The gas temperature fluctuation leads to faster NO release from the particle. The heterogeneous NO formation during the char combustion is further enhanced by the increase in the fluctuation amplitude of gas temperature.

10/02997 Emissions estimation for lignite-fired power plants in Turkey

Vardar, N. and Yumurtaci, Z. *Energy Policy*, 2010, 38, (1), 243–252.

The major gaseous emissions (e.g. sulfur dioxides, nitrogen oxides, carbon dioxide, and carbon monoxide), some various organic emissions (e.g. benzene, toluene and xylenes) and some trace metals (e.g. arsenic, cobalt, chromium, manganese and nickel) generated from lignite-fired power plants in Turkey are estimated. The estimations are made separately for each one of the thirteen plants that produced electricity in 2007, because the lignite-fired thermal plants in Turkey are installed near the regions where the lignite is mined, and characteristics and composition of lignite used in each power plant are quite different from a region to another. Emission factors methodology is used for the estimations. The emission factors obtained from well-known literature are then modified depending on local moisture content of lignite. Emission rates and specific emissions (per MWh) of the pollutants from the plants having no electrostatic precipitators and flue-gas desulfurization systems are found to be higher than emissions from the plants having electrostatic precipitators and flue-gas desulfurization systems. Finally a projection for the future emissions due to lignite-based power plants is given. Predicted demand for the increasing generation capacity based on the lignite-fired thermal power plant, from 2008 to 2017 is around 30%.

10/02998 Evaluation of a condensation particle counter for vehicle emission measurement: experimental procedure and effects of calibration aerosol material

Wang, X. *et al. Journal of Aerosol Science*, 2010, 41, (3), 306–318.

A limit on particle number emission from the exhaust of Euro 5/6 engines will take effect in 2011 and engine exhaust particle number concentrations are required to be measured by particle number counters that meet requirements set forth by the UN/ECE particulate measurement programme (PMP). The TSI Model 3790 engine exhaust condensation particle counter (EECPC) was developed to meet these PMP requirements. This paper describes an experimental study that evaluated the performance of the EECPC. Experimental setup and procedures for calibrating EECPCs were evaluated. It was found that the EECPC counting efficiency strongly depended on the aerosol material. Among several materials tested, the counting efficiencies were highest for poly-α-olefin and lowest for sodium chloride. Errors in the concentration measurement due to the aerosol material dependence were estimated and found to be significant. Considerations for selecting aerosol materials for EECPC calibration are discussed with regard to best match with engine testing conditions.

10/02999 Feasibility analysis of GHG reduction target: lessons from Taiwan's energy policy

Huang, W. M. and Lee, G. W. M. *Renewable and Sustainable Energy Reviews*, 2009, 13, (9), 2621–2628.

It is the opinion of this study that more than 10 years of the United Nations Framework Convention on Climate Change (UNFCCC) negotiations have been wasted on determining the greenhouse gas (GHG) emission targets. This study discussed two approaches of GHG reduction targets: top-down approach and bottom-up. This study criticized the top-down approach for reduction target determination has created a new problem for emission reduction efforts. Using Taiwan as a case study, this study adopted the GACMO model to decompose the energy policy and analysed the cost effectiveness of various reduction strategies. Reviewing the emission reduction measures based on the bottom-up approach is the proper way to address GHG emission reductions. Thus, the countries should refocus on implementation of reduction strategies in the spirit of the UNFCCC. Finally, this study believes that if the reduction cost curves of each nation can be made, the Bali roadmap reached through the 2007 UNFCCC COP13/MOP3 in Bali, Indonesia, can be more defined and practical.

10/03000 Fine particulate matter measurement and international standardization for air quality and emissions from stationary sources

Lee, S. W. *Fuel*, 2010, 89, (4), 874–882.

This paper describes a number of global regulations dealing with very fine ambient particulate matter, $PM_{2.5}$ and PM_{10} and the measurements aspects of $PM_{2.5}$ emission measurement methods for stationary sources, particularly of dilution techniques that promote simulation of atmospheric transformation of stack gases allowing for the use of the resulting near-ambient emission data in source apportionment and health risk studies, along with the current progress on international standardization of source $PM_{2.5}$ measurement methods.

10/03001 Formation of NO_x precursors during the pyrolysis of coal and biomass. Part X: effects of volatile–char interactions on the conversion of coal-N during the gasification of a Victorian brown coal in O_2 and steam at 800 °C

Tian, F.-J. *et al. Fuel*, 2010, 89, (5), 1035–1040.

A novel fluidized-bed/fixed-bed reactor was used to study the effects of volatile–char interactions on the conversion of coal-N during the gasification of a Victorian brown coal at 800 °C. The reactor has the capability of controlling the extent and length of the interactions between volatiles and char. The results indicate that in the absence of volatile–char interactions during gasification in O_2, the lack of abundant H radicals led to negligible formation of NH_3 and HCN from char-N. The presence of volatile–char interactions during the gasification of Victorian brown coal in O_2 at 800 °C drastically enhanced the formation of NH_3 and, albeit to a lesser extent, the formation of HCN. The enhanced conversion of char-N into NH_3 (and HCN) due to the volatile–char interactions is attributed to the presence of H radicals in the volatiles. H radicals in volatiles could 'die off' as they pass through the nascent char bed during the course of volatile–char interactions.

10/03002 *In situ* nitrogen enriched carbon for carbon dioxide capture

Thote, J. A. *et al. Carbon*, 2010, 48, (2), 396–402.

In situ nitrogen-enriched carbon was synthesized from locally available low-cost soybean as the proteinaceous source. The material was synthesized by chemical activation using zinc chloride followed by physical activation using CO_2. The surface area of synthesized nitrogen-enriched carbon was found to be $811\,m^2/g$ which is comparable with commercially available activated carbon. The nitrogen-enriched carbon was having a breakthrough adsorption capacity of 23 mg/g at 120 °C which was almost three times higher in comparison with the commercially available activated carbon for a gas mixture comprising 15% CO_2 balanced with helium. This high adsorption capacity was attributed to the presence of nitrogen group within the carbon matrix, which was estimated to be about 0.64% as determined using the Kjeldahl's method. The presence of different nitrogen-containing groups assisting the adsorption of CO_2 in the synthesized sample was also confirmed by infrared analysis. For checking the consistent performance of the synthesized carbon, a number of multi-cycle adsorption–desorption studies were carried out at 30 and 75 °C in binary mixture of CO_2/N_2.

10/03003 Large-scale diesel engine emission control parameters

Sarvi, A. and Zevenhoven, R. *Energy*, 2010, 35, (2), 1139–1145.

Emission tests were carried out on a large-scale medium-speed supercharged diesel engine (~1 MW per cylinder) with control parameters compression ratio, start of ignition (SOI) and fuel type (light and heavy fuel oil, LFO and HFO). Emissions of NO_x, CO, hydrocarbons (HC), smoke (FSN) and particulate matter (PM) were measured and are discussed in relation to the control parameters. Regarding turbocharger influence on emissions the control parameters by-pass and waste-gate are also briefly addressed. The results show that NO_x, CO and FSN decrease while HC emissions increase with later SOI (more delay) for all loads (25–100%). The influence of compression ratio (CR) on NO_x is the inverse of this; decreasing CR gives increased NO_x. Nozzle design is important for emissions control and less holes and bigger diameter for a certain injection angle seems preferable. Fuel type is important too, and in general LFO produces less gaseous or particulate emissions. Diesel engine turbocharger by-pass and waste-gate valves do affect the emissions. PM emissions were found to decrease with the load (~Bmep) for propulsion mode, showing an increase with load for generator mode for HFO; for LFO decreasing PM emissions were found with increasing load for both generator and propulsion mode.

10/03004 Long-term CO_2 emissions reduction target and scenarios of power sector in Taiwan

Ko, F.-K. *et al. Energy Policy*, 2010, 38, (1), 288–300.

This study analyses a series of carbon dioxide (CO_2) emissions abatement scenarios of the power sector in Taiwan according to the Sustainable Energy Policy Guidelines, which was released by Executive Yuan in June 2008. The MARKAL-MACRO energy model was adopted to evaluate economic impacts and optimal energy deployment for CO_2 emissions reduction scenarios. This study includes analyses of life extension of nuclear power plant, the construction of new nuclear power units, commercialized timing of fossil fuel power plants with CO_2 capture and storage (CCS) technology and two alternative flexible trajectories of CO_2 emissions constraints. The CO_2 emissions reduction target in reference reduction scenario is back to 70% of 2000 levels in 2050. The two alternative flexible scenarios, Rt4 and Rt5, are back to 70% of 2005 and 80% of 2005 levels in 2050. The results show that nuclear power plants and CCS technology will further lower the marginal cost of CO_2 emissions reduction. Gross domestic product (GDP) loss rate in reference reduction scenario is 16.9% in 2050, but 8.9% and 6.4% in Rt4 and Rt5, respectively. This study shows the economic impacts in achieving Taiwan's CO_2 emissions mitigation targets and reveals feasible CO_2 emissions reduction strategies for the power sector.

10/03005 Making carbon dioxide sequestration feasible: toward federal regulation of CO_2 sequestration pipelines

Mack, M. and Endemann, B. *Energy Policy*, 2010, 38, (2), 735–743.

As the USA moves closer to a national climate change policy, it will have to focus on a variety of factors affecting the manner in which the country moves toward a future with a substantially lower carbon footprint. In addition to encouraging renewable energy, smart grid, clean fuels and other technologies, the United States will need to make substantial infrastructure investments in a variety of industries. Among the significant contributors to the current carbon footprint in the USA is the use of coal as a major fuel for the generation of electricity. One of the most important technologies that the USA can employ to reduce its carbon footprint is to sequester the carbon dioxide from coal-fired power plants. This article focuses on the legal and policy issues surrounding a critical piece of the necessary sequestration infrastructure: carbon dioxide pipelines that will carry carbon dioxide from where it is removed from fuel or waste gas streams to where it will be sequestered. Ultimately, this article recommends developing a federally regulated carbon dioxide pipeline program to foster the implementation of carbon sequestration technology.

10/03006 Pre-combustion, post-combustion and oxy-combustion in thermal power plant for CO_2 capture

Kanniche, M. *et al. Applied Thermal Engineering*, 2010, 30, (1), 53–62.

This paper presents a summary of technical-economic studies. It allows evaluating, in the French context, the production cost of electricity derived from coal and gas power plants with the capture of CO_2, and the cost per tonne of CO_2 avoided. Three systems were studied: an integrated gasification combined cycle (IGCC), a conventional combustion of pulverized coal and a natural gas combined cycle. Three main methods were envisaged for the capture of CO_2: pre-combustion, post-combustion and oxy-combustion. For the IGCC, two gasification types have been studied: a current technology based on gasification of dry coal at 27 bars (Shell or GE/Texaco radiant type) integrated into a classical combined cycle providing 320 MWe, and a future technology (planned for about 2015–2020) based on gasification of a coal–water mixture (slurry) that can be compressed to 64 bars (GE/Texaco slurry type) integrated into an advanced combined cycle (type H with steam cooling of the combustion turbine blades) producing a gross power output of 1200 MWe.

10/03007 Reduction of NO emissions in a turbojet combustor by direct water/steam injection: numerical and experimental assessment

Benini, E. *et al. Applied Thermal Engineering*, 2009, 29, (17–18), 3506–3510.

Numerical and experimental investigations are conducted to assess the benefits and drawbacks of both water (mist) and steam direct injection within the combustion chamber of a 200 N static thrust turbojet. For this purpose, a three-dimensional CFD model of the combustion process is implemented where pollutant emissions are calculated; in parallel, a test campaign on the turbojet at sea level static conditions is carried out. In both cases the refrigerant flow is injected directly into the combustor, outside the liner. The aim of the investigations is to evaluate the impact of increasing water and steam flows (ranging from 0% to 200% of the fuel mass flow) onto the emissions levels (NO and CO) of the engine.

10/03008 Regional NO_x emission inversion through a four-dimensional variational approach using SCIAMACHY tropospheric NO_2 column observations

Chai, T. *et al. Atmospheric Environment*, 2009, 43, (32), 5046–5055.

In this paper, the NO_x emission scaling factors applied over the 2001 National Emissions Inventory (NEI) are estimated through a four-dimensional variational (4D-Var) approach using SCIAMACHY (scanning imaging absorption spectrometer for atmospheric chartography) tropospheric NO_2 columns measured during summer 2004. In the 'top-down' approach, two-month average NO_2 columns are assimilated into a regional chemical transport model (CTM), STEM, using different assimilation setups. In a basic setup, NO_x emissions are adjusted by assimilating the NO_2 columns. A more general setup of emission inversion allows the initial O_3 concentrations be adjusted along with the NO_x emissions. A final case is set up to assimilate both the NO_2 columns and O_3 measurement from various platforms while allowing adjustments of both the NO_x emissions and the initial O_3 concentrations. It is found that the addition of O_3 measurements did not improve the NO_x emission inversion. With the NO_x emission at surface and upper levels being adjusted separately, results from four cases show that the elevated NO_x emission reduction ranges from 8.9% to 11.4%, and the surface NO_x emission reduction is up to 6.6%. All the cases show NO_x emission reduction in Ohio valley and Washington, District of Columbia areas.

10/03009 SO_2 policy and input substitution under spatial monopoly

Gerking, S. and Hamilton, S. F. *Resource and Energy Economics*, 2010, 32, (3), 327–340.

Following the US Clean Air Act Amendments of 1990, electric utilities dramatically increased their utilization of low-sulfur coal from the Powder River Basin (PRB). Recent studies indicate that railroads hauling PRB coal exercise a substantial degree of market power and that relative price changes in the mining and transportation sectors were contributing factors to the observed pattern of input substitution. This paper asks to what extent does more stringent SO_2 policy stimulate input substitution from high-sulfur coal to low-sulfur coal when railroads hauling low-sulfur coal exercise spatial monopoly power? The question underpins the effectiveness of incentive-based environmental policies given the essential role of market performance in input, output, and abatement markets in determining the social cost of regulation. This analysis indicates that environmental regulation leads to negligible input substitution effects when clean and dirty inputs are highly substitutable and the clean input market is mediated by a spatial monopolist.

10/03010 Spatio-temporal characteristics of PM10 concentration across Malaysia

Liew, J. *et al. Atmospheric Environment*, 2009, 43, (30), 4584–4594.

In this study, the spatial and temporal variability of the PM10 concentration across Malaysia was analysed by means of the rotated principal component analysis. The results suggest that the variability of the PM10 concentration can be decomposed into four dominant modes, each characterizing different spatial and temporal variations. The first mode characterizes the southwest coastal region of the Malaysian Peninsular with the PM10 showing a peak concentration during the summer monsoon, i.e. when the winds are predominantly southerlies or southwesterlies, and a minimal concentration during the winter monsoon. The second mode features the region of western Borneo with the PM10 exhibiting a concentration surge in August–September, which is likely to be the result of the northward shift of the Inter Tropical Convergence Zone (ITCZ) and the subsequent rapid arrival of the rainy season. The third mode delineates the northern region of the Malaysian Peninsular with strong bimodality in the PM10 concentration. Seasonally, this component exhibits two concentration maxima during the late winter and summer monsoons, as well as two minima during the inter-monsoon periods. The fourth dominant mode characterizes the northern Borneo region which exhibits weaker seasonality of the PM10 concentration. Generally, the seasonal fluctuation of the PM10 concentration is largely associated with the seasonal variation of rainfall in the country. However, in addition to this, the PM10 concentration also fluctuates markedly in two timescale bands i.e. 10–20 days quasi-biweekly (QBW) and 30–60 days lower frequency (LF) band of the intra-seasonal timescales. These intra-seasonal fluctuations show strong seasonality with the largest fraction of variance occurring during the boreal summer and the weakest variance during the winter. Generally, the LF intra-seasonal oscillation is stronger compared to the QBW intra-seasonal band.

10/03011 The contribution of biological particles to observed particulate organic carbon at a remote high altitude site

Wiedinmyer, C. *et al. Atmospheric Environment*, 2009, 43, (28), 4278–4282.

Although a significant fraction of atmospheric particulate mass is organic carbon, the sources of particulate organic carbon (POC) are not always apparent. One potential source of atmospheric POC is biological particles, such as bacteria, pollen, and fungal spores. Measurements of POC and biological particles, including bacteria, fungal spores, and pollen, were made as part of the Storm Peak Aerosol and Cloud Characterization Study in Steamboat Springs, CO in March–April 2008. Biological particles were identified and characterized using several methods. The results suggest that biological particles could account for an average of 40% of the organic carbon mass in particles with aerodynamic diameters less than 10 μm. These estimates of POC mass from biological particles are highly uncertain; however, the results suggest that biological particles could be a significant source of organic aerosol in the background continental atmosphere and further observations are needed to better constrain these estimates.

10/03012 Total suspended particulate matter and toxic elements indoors during cooking with yak dung

Kang, S. *et al. Atmospheric Environment*, 2009, 43, (27), 4243–4246.

Many herders in the Tibetan Plateau still inherit the traditional lifestyle, including living in tents and burning yak dung for fuel. This short correspondence reports a pilot study on indoor air quality in the nomadic tents in the Nam Co region, inland Tibetan Plateau. The results showed very high concentrations of total suspended particles (TSP), averaging at 4.45 $\mathrm{mg\,m^{-3}}$ during the cooking/heating period (with daily value of 3.16 $\mathrm{mg\,m^{-3}}$). Elevated concentrations of toxic element Cd, As and Pb were also found within the tents, averaging 3.16 $\mathrm{\mu g\,m^{-3}}$, 35.00 $\mathrm{\mu g\,m^{-3}}$, and 81.39 $\mathrm{\mu g\,m^{-3}}$ for a day, respectively, which were not only far higher than those of WHO indoor air quality guidelines, but also more than 10^4–10^6 times higher than the outdoor air level in the Nam Co area. The study raises serious concerns over the health of Tibetan herders following their long-term exposure to the tent air.

Hydrocarbon emissions

10/03013 Emissions of gas- and particle-phase polycyclic aromatic hydrocarbons (PAHs) in the Shing Mun Tunnel, Hong Kong

Ho, K. F. *et al. Atmospheric Environment*, 2009, 43, (40), 6343–6351.

Real-world vehicle emission factors for 17 gas and particulate polycyclic aromatic hydrocarbons (PAHs) were quantified in the Shing Mun Tunnel, Hong Kong during summer and winter 2003. Naphthalene, acenaphthylene, and acenaphthene were the most abundant gas PAHs while fluoranthene and pyrene were the most abundant in the particle phase. Most (98%) of the gas PAHs consisted of two- and three-aromatic rings whereas most of the particle-phase PAHs were in four- (~60%) and five-ring (~17%) for fresh exhaust emissions. Average emission factors for the gas- and particle PAHs were 950–2564 $\mathrm{\mu g\,veh^{-1}\,km^{-1}}$ and 22–354 $\mathrm{\mu g\,veh^{-1}\,km^{-1}}$, respectively. Good correlations were found between diesel markers (fluoranthene and pyrene; 0.85) and gasoline markers (benzo[ghi]perylene and indeno[1,2,3-cd]pyrene; 0.96). Higher PAH emission factors were associated with a higher fraction of diesel-fuelled vehicles (DV) passing through the tunnel. Separate emission factors were determined from diesel and non-diesel exhaust by the regression intercept method. The average PAH emission factor (i.e. sum of gas and particle phases) from DV ($3085 \pm 1058\ \mathrm{\mu g\,veh^{-1}\,km^{-1}}$) was five times higher than that from non-diesel-fuelled vehicles (NDV, $566 \pm 428\ \mathrm{\mu g\,veh^{-1}\,km^{-1}}$). Ratios of DV to NDV emission factors were high for diesel markers (>24); and low for gasoline markers (<0.4).

10/03014 Environmental impacts of coal combustion: a risk approach to assessment of emissions

Nelson, P. F. *et al. Fuel*, 2010, 89, (4), 810–816.

This paper summarizes some of the work performed in the Cooperative Research Centre for Coal in Sustainable Development (CCSD) on emissions from current power generation. A comprehensive approach was taken in the CCSD program to assessing environmental issues of concern for the power, and by implication the coal, industries. Here results of sampling on full-scale operating plants are described, and detailed data on emission fluxes, particle size distributions, trace element concentrations as a function of particle size, and speciation of the trace elements are illustrated. The results show that particle capture in electrostatic precipitators (ESPs) is significantly less efficient than in fabric filters (FFs), particularly for submicron material, and that significant enrichment is observed in the finer particle sizes emitted from both ESPs and FFs. Results for the speciation of chromium, arsenic and selenium in coals, bottom ash and fly ash are also presented. The majority of chromium in fly ash is present in the less toxic $\mathrm{Cr^{3+}}$ form. Speciation of arsenic in feed coals is variable but the dominant form of As in fly ash is the less toxic $\mathrm{As^{5+}}$.

10/03015 Estimating Taiwan biogenic VOC emission: leaf energy balance consideration

Chang, K.-H. *et al. Atmospheric Environment*, 2009, 43, (32), 5092–5100.

The goal of the present study is to provide a comprehensive model to estimate biogenic volatile organic compounds (BVOCs) in Taiwan. In addition to metrological data, the model consists of (1) 83 land-use patterns, (2) emission factors for various vegetations, (3) energy balance equation to account for leaf temperature, and (4) correction terms for photosynthetically active radiation. The model output includes four categories of 33 BVOCs [isoprene, methylbutenol (MBO), 14 species of monoterpenes and 17 other BVOCs]. The results of model verification based on several approaches include: (1) predicted isoprene emission flux correlates relatively good with the observed isoprene concentration ($R^2 = 0.66$); (2) correlation between leaf temperature and observed isoprene levels is better than that between ambient temperature and isoprene concentrations ($R^2 = 0.63$ vs 0.58); (3) model-predicted isoprene fluxes match well with observed 3-day diurnal isoprene concentration variations; and (4) subsequent model-predicted $\mathrm{O_3}$ concentrations with the BVOC input obtained in the present study match well than that with previous estimated BVOC data with the observed 6-day diurnal $\mathrm{O_3}$ levels in eight air quality monitoring stations. Based on the meteorological data in 2000, the total emission of BVOCs in Taiwan was simulated to be about 433,000 ton (33% of total VOCs) of which both isoprene and 14 species of monoterpenes account for about 34%, with 17 species of other BVOCs being 31% and <2% contribution from MBO. Total emissions of BVOCs are higher in lower and medium altitude (300–1000 m) mountain areas with an average of around 15–30 $\mathrm{ton\,km^{-2}\,y^{-1}}$. The implication of the other results is also discussed.

10/03016 Hydrocarbon pollution of the Mediterranean coastline of Morocco

Er-Raioui, H. *et al. Ocean & Coastal Management*, 2009, 52, (2), 124–129.

Organic geochemical study of hydrocarbon pollution of the Mediterranean coastline of Morocco (Tangier-Nador) was performed during March–April 2002. It corresponds to a preliminary work representing an initial assessment of oil contamination of Moroccan coast. Three coastal sites corresponding to Tangier, Tetouan and Nador, representing the main built-up area of this marine region, were selected for superficial sediments, water and organism sampling. Results showed high contamination levels in these three selected sites, known as the most exposed areas to urban and industrial discharges. The maximal contamination corresponding to the sum of non-aromatic (NAH) and polycyclic aromatic hydrocarbons (PAH) encountered in sediment samples was about 553 μg/g (dw). Nevertheless, even a small city agglomeration without any industrial activity showed high values reaching 370 μg/g (dw), which confirm the important hydrocarbons input coming from discharges of fishing ships and oil transporting tankers. The obtained results from this survey reflecting in part the important amounts drained via effluents toward the Moroccan Mediterranean coasts, presented to the concerned authorities drove to the realization of the project of treatment of the wastewater. They later expect to lower rates by 50%, which is still insufficient for a fragile ecosystem such as the Mediterranean and sensitive to anthropogenic effects.

10/03017 Levels of polycyclic aromatic hydrocarbons in the bio-oils from induction-heating pyrolysis of food-processing sewage sludges

Tsai, W.-T. *et al. Journal of Analytical and Applied Pyrolysis*, 2009, 86, (2), 364–368.

This study investigated the distribution of 21 target polycyclic aromatic hydrocarbons (PAHs) in the bio-oils, which were produced during the induction-heating pyrolysis of three different food-processing sewage sludges. The total concentrations of these priority PAHs ranged from 298 to 336 $\mathrm{mg\,L^{-1}}$. The levels of PAHs are relatively high in low molecular weight fractions such as naphthalene, acenaphthylene, acenaphthene, fluorene and pyrene, and high molecular weight fractions such as indeno[*1,2,3-cd*]pyrene and dibenz(*a,h*)anthracene. However, in consideration of carcinogenic potency, it was found that dibenz(*a,h*)anthracene comprised a significant proportion of toxic equivalency values for target PAHs present in the bio-oils as a basis for using toxic equivalency factor method.

10/03018 New polycyclic aromatic hydrocarbon (PAH) surface processes to improve the model prediction of the composition of combustion-generated PAHs and soot

Raj, A. *et al. Carbon*, 2010, 48, (2), 319–332.

Two new polycyclic aromatic hydrocarbon (PAH) surface processes are proposed, which can cause dehydrogenation and 'rounding' of PAH molecules. The reaction pathways for both the processes involve decyclization of a 6-member ring present on the PAH surface. 1,6-Hydrogen migration in the bay region formed by nearby carbon atoms provides an alternate route for both the processes to proceed. The energetics and kinetics of the proposed processes are investigated using density functional theory and transition state theory, respectively. The B3LYP functional with the 6–311++G(d,p) basis set is employed for the geometry optimization and vibrational frequency analysis of the chemical species and the transition states. The current PAH growth mechanism is extended by including the new processes. A detailed PAH growth model, the kinetic Monte Carlo-aromatic site (KMC-ARS) model is used to study PAH growth with the extended mechanism. Computed ensembles are generated for large PAHs present in a C_2H_2 flame with 70–320 carbon atoms, and are compared to the experimentally observed ensembles. The inclusion of the new PAH processes in the chemical mechanism was found to improve the predicted composition of the large PAH molecules, especially for the PAHs with 70–200 carbon atoms.

10/03019 Photocatalytic oxidation of polycyclic aromatic hydrocarbons: intermediates identification and toxicity testing

Woo, O. T. *et al. Journal of Hazardous Materials*, 2009, 168, (2–3), 1192–1199.

Polycyclic aromatic hydrocarbons (PAHs) are hydrophobic pollutants and their low water solubility limits their degradation in aqueous solution. The presence of water-miscible solvent such as acetone can increase the water solubility of PAHs, however acetone will also affect the degradation of PAH. In this study the effects of acetone on the photocatalytic degradation efficiency and pathways of five selected PAHs, namely naphthalene (two rings), acenaphthylene (three rings), phenanthrene (three rings), anthracene (three rings) and benzo[a]anthracene (four rings) were investigated. The Microtox® toxicity test was used to determine whether the PCO system can completely detoxify the parental PAHs and its intermediates. The addition of 16% acetone can greatly alter the degradation pathway of naphthalene and anthracene. Based on intermediates identified from degradation of the five PAHs, the location of parental PAHs attacked by reactive free radicals can be correlated with the localization energies of different positions of the compound. For toxicity analysis, irradiation by UV light was found to induce acute toxicity by generating intermediates/degradation products from PAHs and possibly acetone. Lastly, all PAHs ($10\,\mathrm{mg\,l^{-1}}$) can be completely detoxified by titanium dioxide ($100\,\mathrm{mg\,l^{-1}}$) within 24 h under UVA irradiation ($3.9\,\mathrm{mW\,cm^{-2}}$).

10/03020 Polycyclic aromatic hydrocarbon exhaust emissions from different reformulated diesel fuels and engine operating conditions

Borrás, E. *et al. Atmospheric Environment*, 2009, 43, (37), 5944–5952.

The study of light-duty diesel engine exhaust emissions is important due to their impact on atmospheric chemistry and air pollution. In this study, both the gas and the particulate phase of fuel exhaust were analysed to investigate the effects of diesel reformulation and engine operating parameters. The research was focused on polycyclic aromatic hydrocarbon (PAH) compounds on particulate phase due to their high toxicity. These were analysed using a gas chromatography–mass spectrometry (GC–MS) methodology. Although PAH profiles changed for diesel fuels with low-sulfur content and different percentages of aromatic hydrocarbons (5–25%), no significant differences for total PAH concentrations were detected. However, rape oil methyl ester biodiesel showed a greater number of PAH compounds, but in lower concentrations (close to 50%) than the reformulated diesel fuels. In addition, four engine operating conditions were evaluated, and the results showed that, during cold start, higher concentrations were observed for high molecular weight PAHs than during idling cycle and that the acceleration cycles provided higher concentrations than the steady-state conditions. Correlations between particulate PAHs and gas phase products were also observed. The emission of PAH compounds from the incomplete combustion of diesel fuel depended greatly on the source of the fuel and the driving patterns.

Life cycle analysis

10/03021 Alternative fuel buses currently in use in China: life-cycle fossil energy use, GHG emissions and policy recommendations

Ou, X. *et al. Energy Policy*, 2010, 38, (1), 406–418.

The Chinese government has enacted policies to promote alternative vehicle fuels (AVFs) and alternative fuel vehicles (AFVs), including city bus fleets. The life cycle, energy savings (ES) and GHG reduction (GR) profiles of AVFs/AFVs are critical to those policy decisions. The well-to-wheels module of the Tsinghua-CA3EM model is employed to investigate actual performance data. Compared with conventional buses, AFVs offer differences in performance in terms of both ES and GR. Only half of the AFVs analysed demonstrate dual benefits. However, all non-oil/gas pathways can substitute oil/gas with coal. Current policies seek to promote technology improvements and market creation initiatives within the guiding framework of national-level diversification and district-level uniformity. Combined with their actual LC behaviour and in keeping with near- and long-term strategies, integrated policies should seek to (1) apply hybrid electric technology to diesel buses; (2) encourage NG/LPG buses in gas-abundant cities; (3) promote commercialize electric buses or plug-in capable vehicles through battery technology innovation; (4) support fuel cell buses and hydrogen technology R&D for future potential applications; and (5) conduct further research on boosting vehicle fuel efficiency, applying low-carbon transportation technologies, and addressing all resultant implications of coal-based transportation solutions to human health and natural resources.

10/03022 Bioethanol from waste: life cycle estimation of the greenhouse gas saving potential

Stichnothe, H. and Azapagic, A. *Resources, Conservation and Recycling*, 2009, 53, (11), 624–630.

This paper considers two alternative feedstocks for bioethanol production, both derived from household waste – refuse derived fuel (RDF) and biodegradable municipal waste (BMW). Life cycle assessment has been carried out to estimate the GHG emissions from bioethanol using these two feedstocks. An integrated waste management system has been considered, taking into account recycling of materials and production of bioethanol in a combined gasification/biocatalytic process. For the functional unit defined as the 'total amount of waste treated in the integrated waste management system', the best option is to produce bioethanol from RDF – this saves up to 196 kg CO_2 equiv. per tonne of MSW, compared to the current waste management practice in the UK. However, if the functional unit is defined as 'MJ of fuel equiv.' and bioethanol is compared with petrol on an equivalent energy basis, the results show that bioethanol from RDF offers no saving of GHG emissions compared to petrol. For example, for a typical biogenic carbon content in RDF of around 60%, the life cycle GHG emissions from bioethanol are 87 g CO_2 equiv./MJ while for petrol they are 85 g CO_2 equiv./MJ. On the other hand, bioethanol from BMW offers a significant GHG saving potential over petrol. For a biogenic carbon content of 95%, the life cycle GHG emissions from bioethanol are 6.1 g CO_2 equiv./MJ which represents a saving of 92.5% compared to petrol. In comparison, bioethanol from UK wheat saves 28% of GHG while that from Brazilian sugar cane – the best performing bioethanol with respect to GHG emissions – saves 70%. If the biogenic carbon of the BMW feedstock exceeds 97%, the bioethanol system becomes a carbon sequester. For instance, if waste paper with the biogenic carbon content of almost 100% and a calorific value of 18 MJ/kg is converted into bioethanol, a saving of 107% compared to petrol could be achieved. Compared to paper recycling, converting waste paper into bioethanol saves 460 kg CO_2 equiv./t waste paper or eight times more than recycling.

10/03023 Comparative life-cycle assessment of a small wind turbine for residential off-grid use

Fleck, B. and Huot, M. *Renewable Energy*, 2009, 34, (12), 2688–2696.

As the popularity of renewable energy systems grows, small wind turbines are becoming a common choice for off-grid household power. However, the true benefits of such systems over the traditional internal combustion systems are unclear. This study employs a life-cycle assessment methodology in order to directly compare the environmental impacts, net-energy inputs, and life-cycle cost of two systems: a stand-alone small wind turbine system and a single-home diesel generator system. The primary focus for the investigation is the emission of greenhouse gases (GHG) including CO_2, CH_4, and N_2O. These emissions are calculated over the life-cycle of the two systems which provide the same amount of energy to a small off-grid home over a twenty-year period. The results show a considerable environmental benefit for small-scale wind power. The wind generator system offered a 93% reduction of GHG emissions when compared to the diesel system. Furthermore, the diesel generator net-energy input was over 200 MW, while the wind system produced an electrical energy output greater than its net-energy input. Economically, the conclusions were less clear. The assumption was made that diesel fuel cost over the next twenty years was based on May 2008 prices, increasing only in proportion to inflation. As such, the net-present cost of the wind turbine system was 14% greater than the diesel system. However, a larger model wind turbine would likely benefit from the effects of the 'economy of scale,' producing superior results both economically and environmentally.

10/03024 Fuel cycle analysis of TRU or MA burner fast reactors with variable conversion ratio using a new algorithm at equilibrium

Salvatores, M. *et al. Nuclear Engineering and Design*, 2009, 239, (10), 2160–2168.

Partitioning and transmutation (P&T) strategies assessment and implementation play a key role in the definition of advanced fuel cycles, in order to insure both sustainability and waste minimization. Several options are under study worldwide, and their impact on core design and associated fuel cycles are under investigation, to offer a rationale to down selection and to streamline efforts and resources. Interconnected issues like fuel type, minor actinide content, conversion ratio values, etc. need to be understood and their impact quantified. Then, from a practical point of view, studies related to advanced fuel cycles require a considerable amount of analysis to assess performances both of the reactor cores and of the associated fuel cycles. A physics analysis should provide a sound understanding of major trends and features, in order to provide guidelines for more detailed studies. In this paper, it is presented an improved version of a generalization of the Bateman equation that allows performing analysis at equilibrium for a large number of systems. It is shown that the method reproduces very well the results obtained with full depletion calculations. The method is applied to explore the specific issue of the features of the fuel cycle parameters related to fast reactors with different fuel types, different conversion ratios (CR) and different ratios of Pu over minor actinide (Pu/MA) in the fuel feed. As an example of the potential impact of such analysis, it is shown that for cores with CR below ~0.8, the increase of neutron doses and decay heat can represent a significant drawback to implement the corresponding reactors and associated fuel cycles.

10/03025 Greenhouse impact assessment of peat-based Fischer–Tropsch diesel life-cycle

Kirkinen, J. *et al. Energy Policy*, 2010, 38, (1), 301–311.

New raw materials for transportation fuels need to be introduced, in order to fight against climate change and also to cope with increasing risks of availability and price of oil. Peat has been recognized suitable raw material option for diesel produced by gasification and Fischer–Tropsch (FT) synthesis. The energy content of Finnish peat reserves is remarkable. In this study, the greenhouse impact of peat-based FT diesel production and utilization in Finland was assessed from the life-cycle point of view. In 100 year's time horizon the greenhouse impact of peat-based FT diesel is likely larger than the impact of fossil diesel. The impact can somewhat be lowered by producing peat from the agricultural peatland (strong greenhouse gas emissions from the decaying peatlayer are avoided) with new peat production technique, and utilizing the produced biomass from the after-treatment area for diesel also. If diesel production is integrated with pulp and paper mill to achieve energy efficiency benefits and if the electricity demand can be covered by zero emission electricity, the greenhouse impact of peat-based FT diesel reduces to the level of fossil diesel when agricultural peatland is used, and is somewhat higher when forestry-drained peatland is used as raw material source.

10/03026 Life cycle analysis of 4.5 MW and 250 W wind turbines

Tremeac, B. and Meunier, F. *Renewable and Sustainable Energy Reviews*, 2009, 13, (8), 2104–2110.

Electric generation by wind turbine is growing very strongly. However, the environmental impact of wind energy is still a matter of controversy. This paper uses life cycle assessment, comparing two systems: a 4.5 MW and a 250 W wind turbines, to evaluate their environmental impact. All stages of life cycle (manufacturing, transports, installation, maintenance, disassembly and disposal) have been analysed and sensitivity tests have been performed. According to the indexes (PEPBT (primary energy pay back time), CO_2 emissions, etc.), the results show that wind energy is an excellent environmental solution provided first, the turbines are high efficiency ones and implemented on sites where the wind resource is good, second, components transportation should not spend too much energy and, third, recycling during decommissioning should be performed correctly. This study proves that wind energy should become one of the best ways to mitigate climate change and to provide electricity in rural zones not connected to the grid.

10/03027 Life cycle analysis of energy use and greenhouse gas emissions for road transportation fuels in China

Yan, X. and Crookes, R. J. *Renewable and Sustainable Energy Reviews*, 2009, 13, (9), 2505–2514.

Life cycle analysis is considered to be a valuable tool for decision making towards sustainability. Life cycle energy and environmental impact analysis for conventional transportation fuels and alternatives such as biofuels has become an active domain of research in recent years. The present study attempts to identify the most reliable results to date and possible ranges of life cycle fossil fuel use, petroleum use and greenhouse gas emissions for various road transportation fuels in China through a comprehensive review of recently published life cycle studies and review articles. Fuels reviewed include conventional gasoline, conventional diesel, liquefied petroleum gas, compressed natural gas, wheat-derived ethanol, corn-derived ethanol, cassava-derived ethanol, sugarcane-derived ethanol, rapeseed-derived biodiesel and soybean-derived biodiesel. Recommendations for future work are also discussed.

10/03028 Life cycle assessment (LCA) and exergetic life cycle assessment (ELCA) of the production of biodiesel from used cooking oil (UCO)

Peiró, L. T. *et al. Energy*, 2010, 35, (2), 889–893.

The paper assesses the life cycle of biodiesel from used cooking oil (UCO). Such life cycle involves four stages: (1) collection, (2) pre-treatment, (3) delivery and (4) transesterification of UCO. Generally, UCO is collected from restaurants, food industries and recycling centres by authorized companies. Then, UCO is pre-treated to remove solid particles and water to increase its quality. After that, it is charged in cistern trucks and delivered to the biodiesel facility to be then transesterified with methanol to biodiesel. The production of 1 ton of biodiesel is evaluated by a life cycle assessment (LCA) to assess the environmental impact and by an exergetic life cycle assessment (ELCA) to account for the exergy input to the system. A detailed list of material and energy inputs is done using data from local companies and completed using Ecoinvent 1.2 database. The results show that the transesterification stage causes 68% of the total environmental impact. The major exergy inputs are uranium and natural gas. If targets set by the Spanish Renewable Energy Plan are achieved, the exergy input for producing biodiesel would be reduced by 8% in the present system and consequently environmental impacts and exergy input reduced up to 36% in 2010.

10/03029 Life cycle assessment of flax shives derived second generation ethanol fueled automobiles in Spain

González-García, S. *et al. Renewable and Sustainable Energy Reviews*, 2009, 13, (8), 1922–1933.

Biofuel use seems to have certain environmental, energy and socio-economic advantages versus fossil fuel consumption. The substitution of fossil fuels with biofuels can be a useful tool to fulfil the Spanish and European policy in relation to mitigation of greenhouse gas (GHG) emissions and increase the security in energy supply. The continuous increase in energy consumption, dependence on energy and high petroleum prices has motivated increasing support for renewable energy promotion. In Spain (the third ethanol producer in Europe in 2007), ethanol from lignocellulosic feedstocks could be one of the most valuable and interesting possibilities for renewable transportation fuels due to the limited competition with food production and high net reduction of GHG emissions. This study is focused on flax shives, obtained as an agricultural co-product from flax crops dedicated to fibre production for specialty paper pulp manufacture as lignocellulosic biomass to produce second generation ethanol involving the use of cellulosic technology. The life cycle assessment methodology was used to evaluate the environmental impacts of the production and use in a flexi fuel vehicle of ethanol blends (10 and 85% in volume of ethanol with gasoline) versus conventional gasoline, throughout their whole life cycle in order to highlight the main sources of these impacts. The system boundaries include cultivation, extraction, processing and final use of fuels. Mass and economic allocation were considered to determine the effect on the results of different allocation approaches. The results of the study show that the allocation methods are essential for outcomes and decision-making. Using ethanol as transportation fuel could present better environmental performance than conventional gasoline in terms of global warming and fossil fuel consumption according to mass allocation. However, environmental credits could be achieved in terms of acidification, fossil fuel consumption and human toxicity according to economic allocation. Contributions to other impact categories such as eutrophication and photochemical oxidants formation were lower for conventional gasoline regardless of the allocation procedure selected. Agricultural activities related to feedstock production are notable contributors to the environmental performance. Thus, high yielding varieties, reduction of tillage activities and reduction in fertilization should help to reduce these impacts.

10/03030 Life cycle energy efficiency and potentials of biodiesel production from palm oil in Thailand

Papong, S. *et al. Energy Policy*, 2010, 38, (1), 226–233.

Biodiesel production from palm oil has been considered one of the most promising renewable resources for transportation fuel in Thailand. The objective of this study was to analyse the energy performance and potential of the palm oil methyl ester (PME) production in Thailand. The PME system was divided into four stages: the oil palm plantation, transportation, crude palm oil (CPO) production, and transesterification into biodiesel. The results showed that the highest fossil-based energy consumption was in the transesterification process, followed by the plantation, transportation, and CPO production. A net energy value and net energy ratio (NER) of 24.0 MJ/FU and 2.5, respectively, revealed that the PME system was quite energy efficient. In addition, if all the by-products from the CPO production (such as empty fruit branches, palm kernel shells, and biogas) were considered in terms of energy sources, the NER would be more than 3.0. The PME can be a viable substitute for diesel and can decrease the need for oil imports. Based on B100 demand in 2008, PME can be substituted for 478 million litres of diesel. Moreover, with palm oil output potential and B5 (a blend of 5% biodiesel and 95% petroleum diesel by volume) implementation, it can be substituted for 1134 million litres of diesel.

10/03031 Life-cycle carbon and cost analysis of energy efficiency measures in new commercial buildings

Kneifel, J. *Energy and Buildings*, 2010, 42, (3), 333–340.

Energy efficiency in new building construction has become a key target to lower nation-wide energy use. The goals of this paper are to estimate life-cycle energy savings, carbon emission reduction, and cost-effectiveness of energy efficiency measures in new commercial buildings using an integrated design approach, and estimate the implications from a cost on energy-based carbon emissions. A total of 576 energy simulations are run for 12 prototypical buildings in 16 cities, with three building designs for each building-location combination. Simulated energy consumption and building cost databases are used to determine the life-cycle cost-effectiveness and carbon emissions of each design. The results show conventional energy efficiency technologies can be used to decrease energy use in new commercial buildings by 20–30% on average and up to over 40% for some building types and locations. These reductions can often be done at negative life-cycle costs because the improved efficiencies allow the installation of smaller, cheaper HVAC equipment. These improvements not only save money and energy, but reduce a building's carbon footprint by 16% on average. A cost on carbon emissions from energy use increases the return on energy efficiency investments because energy is more expensive, making some cost-ineffective projects economically feasible.

10/03032 Multi-objective design optimization of a natural gas-combined cycle with carbon dioxide capture in a life cycle perspective

Bernier, E. *et al. Energy*, 2010, 35, (2), 1121–1128.

The use of multi-objective optimization techniques is attractive to incorporate environmental objectives into the design of energy conversion systems. A method to locally optimize a given process while considering its global environmental impact by using life cycle assessment (LCA) to account for avoidable and unavoidable off-site emissions for each independent material input is presented. It is applied to study the integration of a CO_2-capture process using monoethanolamine in a natural gas-combined cycle power plant, simultaneously optimizing column dimensions, heat exchange, and absorbent flow configuration with respect to two objectives: the levelized cost of electricity and its life cycle global-warming potential. The model combines a process flow-sheeting model and a separate process-integration model. After optimization using an evolutionary algorithm, the results showed that widening the absorber and generating near-atmospheric pressure steam are cost-effective options but that increasing stripper complexity is less so. With $7.80/GJ natural gas and $20/ton CO_2 handling, the minimum on-site CO_2 abatement cost reaches $62.43/ton on a life cycle basis, achieved with a capture rate of over 90%. Of this, $2.13/ton is related to off-site emissions – a specific advantage of LCA that could help industries and governments anticipate the actual future costs of CO_2 capture.

10/03033 The energy balance in the palm oil-derived methyl ester (PME) life cycle for the cases in Brazil and Colombia

Angarita, E. E. Y. *et al. Renewable Energy*, 2009, 34, (12), 2905–2913.

The use of biodiesel produced from the transesterification of vegetable oils with methanol and ethanol is currently seen as an interesting alternative to fossil fuels. The output/input energy relation in the biodiesel production life cycle can be an important indicator of the techno-economic and environmental feasibility evaluation of production of biodiesel from different oleaginous plants. Due to increasing environmental concerns about the emissions from fuel-derived atmospheric pollutants, alternative sources of energy have been receiving greater attention. This work does not look to carry out a complete life cycle assessment but rather just to focus on the energy balance in the palm oil-derived methyl ester life cycle, taking into account practices in Brazil and Colombia. This work will show the differences between the results attained for the two cases. The output/input energy relation for the evaluated case studies ranged from 3.8 to 5.7, with an average value of 4.8.

16 ENERGY

Supplies, policy, economics, forecasts

10/03034 A note on the long-run elasticities from the energy consumption–GDP relationship

Narayan, P. K. *et al. Applied Energy*, 2010, 87, (3), 1054–1057.

The goal of this paper is to examine the long-run elasticities of the impacts of energy consumption on GDP and GDP on energy consumption. The energy consumption–GDP relationship is amongst the most popular relationships examined in the energy economics literature. The bulk of the extant literature has assumed a positive relationship between energy consumption and real GDP. This analysis shows that in only around 60% of the countries considered the relationship is positive.

10/03035 An integrated tax-subsidy policy for carbon emission reduction

Galinato, G. I. and Yoder, J. K. *Resource and Energy Economics*, 2010, 32, (3), 310–326.

A carbon tax is often cited by economists as an effective instrument to mitigate greenhouse gas emissions, but there is little political interest in the USA. In light of this political unpopularity, the authors develop and examine a net-revenue constrained carbon tax and subsidy program. The optimal revenue constrained tax and subsidy schedule based on this utility maximization model taxes energy sources with high emissions to energy price ratio, and subsidizes sources with low emissions to energy price ratios. This approach may be more palatable than a traditional carbon tax because it can change the relative price of low and high emissions energy sources while providing a mechanism to limit net tax increases and energy price increases. It was found that a constrained tax/subsidy program provides welfare gains relative to a no-tax scenario. Welfare gains are estimated to be 1% and 36% of the welfare gains from a Pigouvian tax for the motor fuels industry and electric power industry, respectively. In contrast, subsidies for low-emitting energy sources funded from general tax funds rather than from high-emission energy tax revenues lead to welfare decreases substantially below the proposed tax/subsidy policy approach.

10/03036 Ancient vernacular architecture: characteristics categorization and energy performance evaluation

Zhai, Z. and Previtali, J. M. *Energy and Buildings*, 2010, 42, (3), 357–365.

Building has significant impacts on the environment and natural resources. The emerging world energy and environment challenges demand a substantial revolution of building design philosophies, strategies, technologies, and construction methods. Vernacular architectures, built by people whose design decisions are influenced by traditions in their culture, have been gleaned through a long period of trial and error and the ingenuity of local builders who possess specific knowledge about their place on the planet, and thus are valuable in promoting climate-specific passive building technologies to modern buildings. This study introduced an approach to categorizing distinct vernacular regions and evaluating energy performance of ancient vernacular homes as well as identifying optimal constructions using vernacular building techniques. The research conducted an extensive computer energy modelling for a number of representative ancient vernacular architectural characteristics observed for different climatic regions. The vernacular test subjects were compared against those established according to the International Energy Conservation Code and those generated by the optimization software. The simulation results of the energy models suggest that considering traditions seen in ancient vernacular architecture as an approach to improving building energy performance is a worthwhile endeavour and a scientific guidance can help enhance the performance. The study indicates that, although many vernacular dwells exist in the world, it is challenging (but desired) to package vernacular architecture traditions and quantitative design knowledge to modern building designers. This project is the first part of a much larger project that intends to create a knowledge base of vernacular building traditions that will include information about not only the energy performance of traditional building techniques, but also address areas of cost, material availability and cultural traditions.

10/03037 Assessment of biofuels supporting policies using the BioTrans model

Lensink, S. and Londo, M. *Biomass and Bioenergy*, 2010, 34, (2), 218–226.

The introduction of advanced, second-generation biofuels is a difficult to forecast process. Policies may impact the timing of their introduction and the future biofuels mix. The least-cost optimization model BioTrans supports policy analyses on these issues. It includes costs for all parts of the supply chain, and endogenous learning for all biofuels technologies, including cost reductions through scale. BioTrans shows that there are significant lock-in effects favouring traditional biofuels, and that the optimal biofuels mix by 2030 is path dependent. The model captures important barriers for the introduction of emerging technologies, thereby providing valuable quantitative information that can be used in analyses of biofuels supporting policies. It is shown that biodiesel from oil crops will remain a cost effective way of producing biofuels in the medium term at moderate target levels. Aiming solely at least-cost biofuel production is in conflict with a longer term portfolio approach on biofuels, and the desire to come to biofuels with the lowest greenhouse gas emissions. Lowering the targets because of environmental constraints delays the development of second-generation biofuels, unless additional policy measures (such as specific sub-targets for these fuels) are implemented.

10/03038 Assessment of current Dutch energy transition policy instruments for the existing housing stock

Tambach, M. *et al. Energy Policy*, 2010, 38, (2), 981–996.

This research assesses to what extent current Dutch energy transition policy instruments for the existing housing stock can fulfil local executive actors' needs and instigate adoption of energy efficiency measures by them. This is done by studying energy policy instruments for the existing housing stock in the Netherlands and in other European countries, and by an empirical research, which analyses barriers and needs of local executive actors. It was found that, despite current Dutch energy transition policy instruments for the existing housing stock seem to fulfil local executive actors' needs to a large extent, complementary policy instruments are needed to stimulate and pressure the incumbent renovation regime. A long-term oriented financial rewarding system is needed to build up a structural market for the deployment of renewables, to increase the number of specialist jobs in the building sector, and to stimulate the development of integrated, standardized, building components. Furthermore, a long-term oriented financial rewarding system for energy efficiency investments in housing renovation projects, and a low VAT rate applied to energy efficient renovation measures, are needed. Finally, enforcement possibilities and sanctions (fines) should become an integrative part of Dutch energy certification regulation to make the certificate become part of a value chain.

10/03039 Beyond the EPBD: the low energy residential settlement Borgo Solare

Aste, N. *et al. Applied Energy*, 2010, 87, (2), 629–642.

The European Directive on Energy Performance of Buildings (EPBD) imposes the adoption of measures for improving the energy efficiency in buildings. These measures should take into account the local weather conditions as well as internal thermal environment and cost-effectiveness. In this respect, Italy is a very interesting benchmark. For Northern Italy, the climatic context is particularly difficult to deal with cold winters and hot summers. The legislations are changing very rapidly, but has not fully adapted to the local context. The considered methodology still involves winter heating while summer cooling is addressed in incomplete and inadequate ways. The energy issue is addressed only partially as final energy consumption, but with little attention to life-cycle analysis. Moreover, the belief that the buildings with high energy savings are too expensive, and therefore not attractive from economic point of view. For these reasons, it is very important to develop case studies to demonstrate the effectiveness of sustainable energy in architecture, according to a holistic approach. This paper describes a detailed techno-economic analysis for Borgo Solare project, an extremely advanced and innovative residential settlement designed on sustainable architecture concepts. One of the most innovative aspects of the project is that it is not just an experimental operation but Borgo Solare is a real urban district, which will be built without public funds and should be inhabited by common people. Excellent energy performance, therefore, must be accompanied by affordable market prices. The energy and economical analysis is presented taking into account also the embodied energy of the building. The results on the performance of a sample building (case study) of this settlement are reported, according to different construction standards: prior to EPBD, present from the EPBD and more efficient developed specifically for the project. It has been shown that using the better design practices and technologies the higher initial embodied energy in a low energy building could quickly paid back during its life span. The economic analysis, in the same way, evidences that higher initial investment in case of energy efficient building could become economically convenient during the life span of the building. This kind of analysis is essential to determine the actual sustainability of a building.

10/03040 Carbon sequestration versus bioenergy: a case study from South India exploring the relative land-use efficiency of two options for climate change mitigation

Rootzén, J. M. *et al. Biomass and Bioenergy*, 2010, 34, (1), 116–123.

This case study has been carried out as a comparison between two different land-use strategies for climate change mitigation, with possible application within the clean development mechanisms. The benefits of afforestation for carbon sequestration versus for bioenergy production are compared in the context of development planning to meet increasing domestic and agricultural demand for electricity in Hosahalli village, Karnataka, India. One option is to increase the local biomass based electricity generation, requiring an increased biomass plantation area. This option is compared with fossil based electricity generation where the area is instead used for producing wood for non-energy purposes while also sequestering carbon in the soil and standing biomass. The different options have been assessed using the PRO-COMAP model. The ranking of the different options varies depending on the system boundaries and time period. Results indicate that, in the short term (30 years) perspective, the mitigation potential of the long rotation plantation is largest, followed by the short rotation plantation delivering wood for energy. The bioenergy option is however preferred if a long-term view is taken. Short rotation forests delivering wood for short-lived non-energy products have the smallest mitigation potential, unless a large share of the wood products are used for energy purposes (replacing fossil fuels) after having served their initial purpose. If managed in a sustainable manner all of these strategies can contribute to the improvement of the social and environmental situation of the local community.

10/03041 China's energy situation in the new millennium

Ma, H. *et al. Renewable and Sustainable Energy Reviews*, 2009, 13, (8), 1781–1799.

Many are interested in China's energy situation, however, many energy-related issues in China still remain unanswered, for example, what are the potential forces driving energy demand and supply? Previous reviews focused only on fossil fuel-based energy and ignored other important elements including renewable and 'clean' energy sources. The work presented here is intended to fill this gap by bringing the research on fossil-based and renewable energy economic studies together and identifying the potential drivers behind both energy demand and supply to provide a complete picture of China's energy situation in the new millennium. This will be of interest to anyone concerned with the development of China's economy in general and the energy economy, in particular.

10/03042 Cleanroom energy efficiency strategies: modeling and simulation

Kircher, K. *et al. Energy and Buildings*, 2010, 42, (3), 282–289.

To maintain ultra-low particle concentrations, cleanrooms can require several hundred air changes per hour. These ventilation rates make cleanrooms 30–50 times more energy intensive than the average American commercial building. There are an estimated 12 million m^2 of cleanroom space in the USA, consuming over 370 PJ of energy each year. This paper explores opportunities to improve the energy efficiency of cleanrooms while maintaining or improving operating conditions. This paper documents the modelling of a 1600 m^2 cleanroom in upstate New York. The TRNSYS model includes TMY2 weather data; building geometry and material properties; empirical data on occupancy, lighting and process equipment; and sophisticated HVAC systems. The model was validated based on metered steam, chilled water and electricity usage. Under 8% error was achieved in all fields. Four strategies were simulated: a heat recovery system for exhaust air, resulting in an 11.4% energy reduction with a 2.7-year simple payback; solar preheating of desiccant dehumidifier regeneration air (2.4% energy reduction, 11.5-year payback); improved lighting controls (0.3% energy reduction, 1.5-year payback); and demand-controlled filtration (4.4% energy reduction, 3.1-year payback). Implementation of recommended strategies is predicted to save 9 TJ, 862 tonnes of CO_2, and $164k annually.

10/03043 Community energy planning in Canada: the role of renewable energy

St. Denis, G. and Parker, P. *Renewable and Sustainable Energy Reviews*, 2009, 13, (8), 2088–2095.

An emerging trend in Canada is the creation of community energy plans, where decisions that used to be left to regional level energy agencies or private individuals are now being considered at the community level. A desire to reduce greenhouse gas emissions and to become more energy self-sufficient is driving this change. Theoretically, local level management is desirable because it achieves these goals through improvements in the three areas of energy efficiency, energy conservation and switching to renewable energy sources. The analysis of 10 of the first community energy plans in Canadian communities, ranging in population size from 500 to one million, finds that communities are choosing policies and programs centred on increasing energy efficiency and conservation while renewable energy receives much less attention. Municipal operations were called upon to set higher targets than the general community. Communities that recognized the substantial potential of renewable energy often focused on technologies that the municipal sector could implement, such as biofuels for their transportation fleet. Wind, passive solar design, solar photovoltaics and solar thermal options were only recommended in a few cases. Overall, only one of the five larger communities (Calgary) recommended implementing multiple renewable energy technologies while three of the five smaller communities proposed multiple renewable energy sources. The implication is that smaller and more remote communities may be the most willing to lead in the planned introduction of renewable energy systems.

10/03044 Comparison of the evolution of energy intensity in Spain and in the EU15. Why is Spain different?

Mendiluce, M. *et al. Energy Policy*, 2010, 38, (1), 639–645.

Energy intensity in Spain has increased since 1990, while the opposite has happened in the EU15. Decomposition analysis of primary energy intensity ratios has been used to identify which are the key sectors driving the Spanish evolution and those responsible for most of the differences with the EU15 energy intensity levels. It is also a useful tool to quantify which countries and economic sectors have had most influence in the EU15 evolution. The analysis shows that the Spanish economic structure is driving the divergence in energy intensity ratios with the EU15, mainly due to strong transport growth, but also because of the increase of activities linked to the construction boom, and the convergence to EU levels of household energy demand. The results can be used to pinpoint successful EU strategies for energy efficiency that could then be used to improve the Spanish metric.

10/03045 Critical analysis of the European Union directive which regulates the use of biofuels: an approach to the Spanish case

Sobrino, F. H. and Monroy, C. R. *Renewable and Sustainable Energy Reviews*, 2009, 13, (9), 2675–2681.

In recent times, the global debate on the environment has been centred on CO_2 emissions. This gas is the major cause of the 'greenhouse effect' and people are more concerned with the idea that the emissions of this gas should be minimized. As a result of this concern, the Kyoto Protocol was enacted and subscribed to by many countries, setting the maximum gas emissions for them. Fossil fuels are a major source of CO_2 emissions. In 2003 the European Union (EU) directive 2003/30/EC [2003/30/EC Directive of the European Parliament and the Council – 8 May 2003. On the promotion of the use of biofuels or other renewable fuels for transport] was developed with the aim of promoting the use of biofuels as a substitute for diesel or petrol among European Union countries as well as to contribute to fulfilling the commitments on climate change, security of supply in environmentally friendly conditions and the promotion of renewable energy sources. In order to achieve these goals, the directive forces all EU members to ensure that at least 5.75% of all petrol and diesel fuels sold for transport purposes are biofuels before 31 December 2010. EU countries have social and economic characteristics unique to themselves. The energy dependence from foreign sources, the features of the agricultural sector or the degree of industrialization varies greatly from one country to another. In this context, it is questionable whether the obligation imposed by this directive applies to achieve uniform and/or identical goals in each of the countries involved and whether the actions of the various governments are also aligned with these goals.

10/03046 Developing the geothermal resources map of Iran

Yousefi, H. *et al. Geothermics*, 2010, 39, (2), 140–151.

Geothermal exploration involves a high degree of uncertainty and financial risk, and requires reliable exploration data to constrain development decisions. The paper describes a geothermal exploration and resource identification method that is based on building a map of potential geothermal resource areas by combining geological, geochemical and geophysical datasets; it is a powerful tool for visualizing new and existing data during decision-making processes. By performing suitability analysis and geothermal area identification, and by establishing criteria to define geothermal resources with development potential, a map of Iran was constructed highlighting 18 promising areas.

10/03047 Economy and CO_2 emissions trade-off: a systematic approach for optimizing investments in process integration measures under uncertainty

Svensson, E. and Berntsson, T. *Applied Thermal Engineering*, 2010, 30, (1), 23–29.

This study presents a systematic approach for taking into account the resulting CO_2 emissions reductions from investments in process integration measures in industry when optimizing those investments under economic uncertainty. The fact that many of the uncertainties affecting investment decisions are related to future CO_2 emissions targets and policies implies that a method for optimizing not only economic criteria, but also greenhouse gas reductions, will provide better information to base the decisions on, and possibly also result in a more robust solution. Te proposed approach applies a model for optimization of decisions on energy efficiency investments under uncertainty and regard the decision problem as a multiobjective programming problem. The method is applied to a case of energy efficiency investments at a chemical pulp mill. The case study is used to illustrate that the proposed method provides a good framework for decision-making about energy efficiency measures when considerations regarding greenhouse gas reductions influence the decisions. The authors show that by setting up the problem as a multiobjective programming model and at the same time incorporating uncertainties, the trade-off between economic and environmental criteria is clearly illustrated.

10/03048 Energy consumption and economic development in Sub-Sahara Africa

Kebede, E. *et al. Energy Economics*, 2010, 32, (3), 532–537.

Sub-Saharan African countries' economic development is dependent on energy consumption. This paper assesses total energy demand, which is composed of traditional energy (wood fuel) and commercial energy (electricity and petroleum), in the central, east, south, and west regions of Sub-Saharan Africa. Cross-sectional time series data for 20 countries in 25 years are analysed, and the results of the study show that wood fuel accounts for 70% of energy consumption, followed by petroleum, with most industrial activities utilizing some form of wood fuel. Regression results suggest that energy demand is inversely related to the price of petroleum and industrial development, but positively related to GDP, population growth rate, and agricultural expansion, and that price elasticity is less than one. The model results also show that there are regional differences in energy demand. In addition, the interaction of population growth rates by regions generates mixed results, and there are regional differences in the use of commercial energy consumption, and GDP growth. The findings of this study suggest that countries must diversify their energy sources and introduce energy-efficient devices and equipment at all levels of the economy to improve GDP growth rate and GDP per capita.

10/03049 Energy consumption and income: a semiparametric panel data analysis

Nguyen-Van, P. *Energy Economics*, 2010, 32, (3), 557–563.

This paper proposes a semiparametric analysis for the study of the relationship between energy consumption per capita and income per capita for an international panel dataset. It shows little evidence for the existence of an environmental Kuznets curve for energy consumption. Energy consumption increases with income for a majority of countries and then stabilizes for very high income countries. Neither changes in energy structure nor macroeconomic cycle/technological change have significant effect on energy consumption.

10/03050 Energy deprivation dynamics and regulatory reforms in Europe: evidence from household panel data

Poggi, A. and Florio, M. *Energy Policy*, 2010, 38, (1), 253–264.

The typical ingredients of energy reforms in the European Union (EU) in the 1990s were full or partial privatization, vertical disintegration and liberalization. This paper analyses the effects of energy reforms on the probability of households experiencing deprivation, defined as difficulty in paying the bills. The authors used two sets of micro-data. First, the European Community Household Panel (ECHP), a large EU survey, offered evidence on people who report having been unable to pay scheduled utility bills. Seven European countries were considered: Denmark, Belgium, France, Ireland, Italy, the Netherlands and Spain, and eight ECHP waves (1994–2001), with around 28,000 observations. Second, micro-data was used from the European Statistics on Income and Living Conditions survey (EU-SILC) 2004–2005, with around 84,000 observations. The countries included were Belgium, France, Ireland, Italy, Spain, Austria, Finland, Luxembourg, Norway and Sweden. As indicators of regulatory reforms in the same countries and years ECTR (formerly REGREF) was used, a database provided by the OECD. In both samples evidence was found that privatization increases the probability of households experiencing deprivation. Vertical disintegration has a similar effect and also increases the persistence in the status of household deprivation. Liberalization has no statistically significant effect.

10/03051 Estimation of electricity demand of Iran using two heuristic algorithms

Amjadi, M. H. *et al. Energy Conversion and Management*, 2010, 51, (3), 493–497.

This paper deals with estimation of electricity demand of Iran based on economic indicators using particle swarm optimization (PSO) algorithm. The estimation is based on gross domestic product (GDP), population, number of customers and average price electricity by developing two different estimation models: a linear model and a non-linear model. The proposed models are obtained based upon available actual data of 21 years; since 1980–2000. Then the models obtained are used to estimate the electricity demand of the target years; for a period of time, e.g. 2001–2006 and the results obtained are compared with the actual demand during this period. Furthermore, to validate the results obtained by PSO, genetic algorithm (GA) is applied to solve the problem. The results show that the PSO is a useful optimization tool for solving the problem using two developed models and can be used as an alternative solution to estimate the future electricity demand.

10/03052 European biomass resource potential and costs

de Wit, M. and Faaij, A. *Biomass and Bioenergy*, 2010, 34, (2), 188–202.

The objective of this study is to assess the European (EU-27+ and Ukraine) cost and supply potential for biomass resources. Three methodological steps can be distinguished: (1) an evaluation of the available 'surplus' land, (2) a modelled productivity and (3) an economic assessment for 13 typical bioenergy crops. Results indicate that the total available land for bioenergy crop production – following a 'food first' paradigm – could amount to 900,000 km^2 by 2030. Three scenarios were constructed that take into account different development directions and rates of change, mainly for the agricultural productivity of food production. Feedstock supply of dedicated bioenergy crop estimates varies between 1.7 and 12.8 EJ y^{-1}. In addition, agricultural residues and forestry residues can potentially add to this 3.1–3.9 EJ y^{-1} and 1.4–5.4 EJ y^{-1} respectively. First-generation feedstock supply is available at production costs of 5–15 € GJ^{-1} compared to 1.5–4.5 € GJ^{-1} for second-generation feedstocks. Costs for agricultural residues are 1–7 € GJ^{-1} and forestry residues 2–4 € GJ^{-1}. Large variation exists in biomass production potential and costs between European regions, 280 (NUTS2) regions specified. Regions that stand out with respect to high potential and low costs are large parts of Poland, the Baltic states, Romania, Bulgaria and Ukraine. In western Europe, France, Spain and Italy are moderately attractive following the low-cost, high-potential criterion.

10/03053 Impact analysis of carbon tax on the renewal planning of energy supply system for an office building

Amano, Y. *et al. Energy*, 2010, 35, (2), 1040–1046.

An optimal planning method is proposed for the renewal-planning problem of an energy supply system installed into building from economic viewpoint. In this method, the objective function to be minimized is the average annual total cost during the evaluation period of the objective system based on the annualized costs method, and the renewal year is considered as a decision variable together with the renewal system's structure, equipment capacities, and system's operational strategy. This problem is formulated as one of the mixed-integer linear programming problem, and a numerical study is carried out for an office building with the total floor area of 15,000 m^2 by using the GAMS/CPLEX solver. Impact analysis of the carbon tax introduction is mainly studied on the renewal planning mentioned above, and the following results are obtained: (a) The optimal renewal strategy is not affected by the future carbon tax introduction at the standard rate such as 655 Japanese Yen/t-CO$_2$ (=4.1 €/t-CO$_2$) argued presently in Japan. (b) By increasing the above tax rate more than 13 times higher, structure of the optimal renewal system changes suddenly, and equipment with high energy conversion efficiency becomes to be installed in spite of its expensive initial cost.

10/03054 Influences of new socialist countryside construction on the energy strategy of china and the countermeasures

Yang, P. Y. *et al. Energy*, 2010, 35, (2), 698–702.

The fast-growing Chinese economy will inevitably need more and more energy. This not only makes China's energy shortage situation severer, but also causes more and more worries from the countries all over the world, especially those developed countries. In this paper, China's energy state is analysed and the influences of promoting new socialist countryside construction on China's energy source problem and its energy strategy making are discussed. It is stressed in this paper that in drawing the national energy development plan, it is of vital importance to take the impacts of new socialist countryside construction on energy production, supply and consumption into consideration. Traditional mineral energy supply that has been used for towns and cities should not be simply copied to solve the energy problem in countryside construction. The best choice for combating the huge energy increase resulted from speeding up the countryside construction is promoting utilization of biomass and solar energy and various advanced energy technologies. To make the utilization of biomass and solar energy and various advanced energy technologies in countryside, the government should give necessary technical and financial supports.

10/03055 Interfuel substitution in the United States

Serletis, A. *et al. Energy Economics*, 2010, 32, (3), 737–745.

This paper uses the locally flexible translog functional form to investigate the demand for energy and interfuel substitution in the USA and to provide a comparison of the results with most of the existing empirical energy demand literature. The evidence from this study indicates that the interfuel elasticities of substitution are (in general) consistently below unity, revealing the limited ability to substitute one source of energy for another and suggesting that fossil fuels will continue to maintain their major role as a source of energy in the near future.

10/03056 Managing emissions from highly industrialized areas: regulatory compliance under uncertainty

El-Fadel, M. *et al. Atmospheric Environment*, 2009, 43, (32), 5015–5026.

The use of regulatory and compliance-based modelling for air quality impact assessment is invariably relied upon to predict future air quality under various management scenarios particularly where air quality monitoring data are limited. This paper examines the dispersion from a multi-stack cement manufacturing complex with associated quarries and transport activities for regulatory compliance under uncertain emission and meteorological conditions. The concentrations of CO, NO$_x$, SO$_2$ and PM at sensitive receptor locations were used as indicators in comparison to World Health Organization (WHO) interim guidelines. Exceedance exposure areas were delineated under bounded uncertainties in input emission factors and meteorological parameters. Planning and management initiatives were tested to control/minimize potential exposure. Compared to the case of low emissions and actual meteorological conditions, the consideration of worst emissions coupled to worst meteorological conditions enlarged the boundaries of the exceedance exposure areas considerably. The implementation of best available technologies and enforcement of emission standards improved air quality in the region significantly and lowered the exposure at many population centres to below health standards. Uncertainty in the output of atmospheric dispersion models continues to play a significant role to be considered at the point where science is translated into political decision making.

10/03057 Metrological management evaluation based on ISO10012: an empirical study in ISO-14001-certified Spanish companies

Beltrán, J. *et al. Energy*, 2010, 35, (1), 140–147.

Environmental management systems based on the ISO 14001 standard rely strongly on metrological measurement and confirmation processes to certify the extent to which organizations monitor and improve their environmental behaviour. Nevertheless, the literature lacks in studies that assess the influence of these metrological processes on the performance of environmental management in organizations, even now that the international standard ISO 10012 is already available to establish requisites and guidelines for the development of a metrological management system that is compatible with any other standardized management system. This work seeks to assess that influence through the development of an evaluation model for metrological management, which is then validated through an experimental analysis of the results obtained from the application of an audit process in 11 Spanish companies, all ISO-14001-certified and operating in different industrial sectors.

10/03058 Nonlinearity and intraday efficiency tests on energy futures markets

Wang, T. and Yang, J. *Energy Economics*, 2010, 32, (2), 496–503.

Using high frequency data, this paper examines the intraday efficiency of four major energy (crude oil, heating oil, gasoline, natural gas) futures markets. In contrast to earlier studies which focus on in-sample evidence and assume linearity, the paper employs various nonlinear models and several model evaluation criteria to examine market efficiency in an out-of-sample forecasting context. Overall, there is evidence for intraday market inefficiency of two of the four energy future markets (heating oil and natural gas), which exists particularly during the bull market condition but not during the bear market condition. The evidence is also robust against the data-snooping bias and the model overfitting problem, and its economic significance can be very substantial.

10/03059 Nuclear energy consumption and economic growth in nine developed countries

Wolde-Rufael, Y. and Menyah, K. *Energy Economics*, 2010, 32, (3), 550–556.

This article attempts to test the causal relationship between nuclear energy consumption and real GDP for nine developed countries for the period 1971–2005 by including capital and labour as additional variables. Using a modified version of the Granger causality test developed elsewhere, the authors found a unidirectional causality running from nuclear energy consumption to economic growth in Japan, Netherlands and Switzerland; the opposite uni-directional causality running from economic growth to nuclear energy consumption in Canada and Sweden; and a bi-directional causality running between economic growth and nuclear energy consumption in France, Spain, the United Kingdom and the United States. In Spain, the United Kingdom and the USA, increases in nuclear energy consumption caused increases in economic growth implying that conservation measures taken that reduce nuclear energy consumption may negatively affect economic growth. In France, Japan, Netherlands and Switzerland increases in nuclear energy consumption caused decreases in economic growth, suggesting that energy conservation measure taken that reduce nuclear energy consumption may help to mitigate the adverse effects of nuclear energy consumption on economic growth. In Canada and Sweden energy conservation measures affecting nuclear energy consumption may not harm economic growth.

10/03060 Subsidy policy and the enlargement of choice

Srinivasan, S. *Renewable and Sustainable Energy Reviews*, 2009, 13, (9), 2728–2733.

Development is the enlargement of people's choices. Optimal subsidy policy is intended to create the right incentives for each of the value chain participants. This paper contends that the interest subsidy offered by the Indian federal Ministry of New and Renewable Energy for solar thermal systems, through mainstream banking channels is superior in intent and outcome compared to the capital subsidy as currently offered for solar PV systems, routed through government controlled delivery channels. The interest subsidy enhances innovation, improves service delivery and expands the range of product available to consumers enjoying a wide range of endowments, thus leading to more inclusive development. The simple monopoly model developed elsewhere is applied to the context of solar home systems to demonstrate price reduction and choice expansion in a liberalized market, facilitated by an interest subsidy scheme.

10/03061 The causality between energy consumption and economic growth: a multi-sectoral analysis using non-stationary cointegrated panel data

Costantini, V. and Martini, C. *Energy Economics*, 2010, 32, (3), 591–603.

The increasing attention given to global energy issues and the international policies needed to reduce greenhouse gas emissions have given a renewed stimulus to research interest in the linkages between the energy sector and economic performance at country level. This study analyses the causal relationship between economy and energy by adopting a vector error correction model for non-stationary and cointegrated panel data with a large sample of developed and developing countries and four distinct energy sectors. The results show that alternative country samples hardly affect the causality relations, particularly in a multivariate multi-sector framework.

10/03062 The long-run impact of energy prices on world agricultural markets: the role of macro-economic linkages

Gohin, A. and Chantret, F. *Energy Policy*, 2010, 38, (1), 333–339.

The world prices of some food and energy products have followed similar large swings in recent years. The authors investigated the long-run relationship between these prices using a world computable general equilibrium model with detailed representations of food and energy markets. Particular attention is paid to specifying macro-economic linkages which have often been overlooked in recent analysis and debate. It was found that the omission of these macro-economic linkages has a substantial bearing on this relationship. A positive relationship due to the cost push effect has been identified in most analysis, but it was found that the introduction of the real income effect may indeed imply a negative relationship between world food and energy prices.

10/03063 The REFUEL EU road map for biofuels in transport: application of the project's tools to some short-term policy issues

Londo, M. *et al. Biomass and Bioenergy*, 2010, 34, (2), 244–250.

The current hot debate on biofuels calls for a balanced and realistic long-term strategy for biofuels. The REFUEL project provides several ingredients for such a strategy. Analyses in this project indicate that domestically produced biofuels can cover a significant share of European Union (EU) fuel demand in the coming decades, with the EU-12 new member states and Ukraine as most promising regions. This potential can be realized with residual streams and on existing agricultural land, without conversion of nature reserves, for example. Second-generation biofuels are essential for the long-term success of biofuels due to their superior performance in many ways. But generally, the key challenge for the near future would be how to enhance the development of biofuels in a responsible way, i.e. stimulating the production chains with the best performance, and preventing negative impacts, e.g. by paying careful attention to possible system impacts of biofuel production such as indirect land-use changes and rising food prices. Finally, second-generation biofuels require specific policy: the precursor role of the first generation is overrated, both in technical terms as well as in their role as market precursors. When it comes to synergies, second-generation biofuels might benefit more from other developments in the energy sector, such as initiatives in co-firing of biomass for (heat and) power, than from first-generation biofuels, also because of the public resistance that the latter induce.

10/03064 Vegetable oil market and biofuel policy: an asymmetric cointegration approach

Peri, M. and Baldi, L. *Energy Economics*, 2010, 32, (3), 687–693.

This paper analyses the long-run relationship between vegetable oil prices and conventional diesel prices in the European Union (EU) for the period 2005–2007. The authors applied recent developments in the threshold cointegration approach to investigate the presence of asymmetric dynamic adjusting processes between the prices of rapeseed oil, sunflower oil, and soybean oil, and the price of a mineral oil: diesel. The results presented suggest a two-regime threshold cointegration model only for the rapeseed oil–diesel price pair. Thus, the rapeseed oil price adjusts rapidly to its long-run equilibrium, determined by fossil diesel prices, but this adjustment is asymmetric: it differs if the divergence between the two prices is above or below a critical threshold. Consequently, rapeseed oil appears particularly exposed to external shocks deriving from global political scenarios, suggesting the reassessment of the high quota (80%) of EU biodiesel represented by this vegetable oil.

Energy conservation

10/03065 A hybrid decision support system for sustainable office building renovation and energy performance improvement

Juan, Y.-K. *et al. Energy and Buildings*, 2010, 42, (3), 290–297.

Energy consumption of buildings accounts for around 20–40% of all energy consumed in advanced countries. Over the past decade, more and more global organizations are investing significant resources to create sustainably built environments, emphasizing sustainable building renovation processes to reduce energy consumption and carbon dioxide emissions. This study develops an integrated decision support system to assess existing office building conditions and to recommend an optimal set of sustainable renovation actions, considering trade-offs between renovation cost, improved building quality, and environmental impacts. A hybrid approach that combines A* graph search algorithm with genetic algorithms (GA) is used to analyse all possible renovation actions and their trade-offs to develop the optimal solution. A two-stage system validation is performed to demonstrate the practical application of the hybrid approach: zero-one goal programming (ZOGP) and genetic algorithms are adopted to validate the effectiveness of the algorithm. A real-world renovation project is introduced to validate differences in energy performance projected for the renovation solution suggested by the system. The results reveal that the proposed hybrid system is more computationally effective than either ZOGP or GA alone. The system's suggested renovation actions would provide substantial energy performance improvements to the real project if implemented.

10/03066 An investigation into the heat consumption in a low-energy building

Wojdyga, K. *Renewable Energy*, 2009, 34, (12), 2935–2939.

The results of 5-year study of the heat consumption in a single-storey terraced low-energy residence are presented. The house is part of a 40-building Warsaw housing estate Wilanow–Zawady.

10/03067 Analysis on energy saving potential of integrated supermarket HVAC and refrigeration systems using multiple subcoolers

Yang, L. and Zhang, C.-L. *Energy and Buildings*, 2010, 42, (2), 251–258.

The paper presents a model-based analysis on the energy saving potential of supermarket HVAC (heating, ventilating, and air-conditioning) and refrigeration systems using multiple subcoolers among the high-temperature HVAC system, the medium-temperature refrigeration system, and the low-temperature refrigeration system. The principle of energy reduction is to have the higher COP (coefficient of performance) system generate more cooling capacity to increase the cooling capacity or reduce the power consumption of the lower COP system. The subcooler could be placed between the medium-temperature and low-temperature systems, between the high-temperature and medium-temperature systems, and between the high-temperature and low-temperature systems. All integration scenarios of adding one, two and three subcoolers have been investigated. The energy saving potential varies with the load ratio between high-, medium- and low-temperature systems, COP of three systems, and the 'on-off' duty time of HVAC system. The optimal sequence of adding subcoolers is also proposed.

10/03068 Cooling output optimization of an air handling unit

Kusiak, A. and Li, M. *Applied Energy*, 2010, 87, (3), 901–909.

A data-driven optimization approach for minimization of the cooling output of an air handling unit (AHU) is presented. The models used in this research are built with data mining algorithms. The performance of dynamic models build by four different data mining algorithms is studied. A model extracted by a neural network is selected for identifying the functional mapping between specific outputs and controllable and non-controllable inputs of the AHU. To minimize the cooling output while maintaining the corresponding thermal properties of the supply air within a certain range, a bi-objective optimization model is proposed. The evolutionary strategy algorithm is applied to solve the optimization problem with the optimal control settings obtained at each time stamp. The minimized AHU's cooling output reduces the chiller's load, which leads to energy savings.

10/03069 Criteria for energy efficient lighting in buildings

Ryckaert, W. R. *et al. Energy and Buildings*, 2010, 42, (3), 341–347.

In order to assess the energy efficiency of an indoor lighting installation, a criterion for the installed electrical power is proposed which is broadly applicable and easy to use. Introducing target values for lamps and gear and taking into account some basic lighting comfort requirements, the maximum electrical power to be installed can be predicted for any kind of application. Herewith, one or more task areas with appropriate target illuminance values may be defined. The key parameter of the criterion is the analytical expression for the target use as a function of common lighting design parameters. Two practical examples illustrate the validity of the criterion. In a first example, a general case where the task area is coincident with a reference plane parallel with the floor has been studied. The values obtained converge to actual target values in current practice. In a second example, the lighting design of a store with many vertical task areas is explained. These cases illustrate the advantages of the criterion as compared to energy evaluation criteria based on the normalized power density. From 2010 on, the proposed criterion will be used in Flanders to assign grants for a relighting or new lighting.

10/03070 Development of an intelligent indoor environment and energy management system for greenhouses

Kolokotsa, D. *et al. Energy Conversion and Management*, 2010, 51, (1), 155–168.

The microclimate control in a greenhouse is a complicated procedure since the variables that influence it are several and dependant on each other. This work is an effort of integrating these variables in a common control methodology through the development of an intelligent environment and energy management system for greenhouses. Two fuzzy logic controllers are developed, embodying the expert knowledge of agriculturists and indoor environment experts. These controllers consist of fuzzy P (Proportional) and PD (Proportional-Derivative) control using desired indoor climatic set-points. The factors being monitored are the greenhouse's indoor illuminance, temperature, relative humidity, CO_2 concentration and the outside temperature. Output actuations include: heating units, motor-controlled windows, motor-controlled shading curtains, artificial lighting, CO_2 enrichment bottles and water fogging valves. These controllers are prototyped in a Matlab environment and simulated using a greenhouse model, which is implemented as a module within the TRNSYS software. The system is tested in a greenhouse located in MAICh (Mediterranean Agronomic Institute of Chania). The overall installation is based on Local Operating Network (LonWorks) protocol.

10/03071 Energy efficiency improvement of dryer section heat recovery systems in paper machines – a case study

Sivill, L. and Ahtila, P. *Applied Thermal Engineering*, 2009, 29, (17–18), 3663–3668.

Modern paper machines are equipped with heat recovery systems that transfer heat from the humid exhaust air of the paper machine's dryer section to different process streams. As a result of process changes, the heat recovery systems may operate in conditions far from the original design point, creating a significant potential for energy efficiency improvement. In this paper the authors demonstrate this potential with a case study of three operating paper machines. Both operational and structural improvement opportunities are examined. Since the existing retrofit methodologies for heat exchanger networks can not be applied to cases with condensing air, thermodynamic simulation models presented earlier are used to assess the effects of possible changes on the existing heat recovery systems. In order to reduce the required processing time of the simulation models, only a limited number of pre-screened retrofit designs are considered. The pre-screening is carried out on the basis of guidelines presented earlier. The analysis in the case mill revealed savings of 110 GWh/a in process heat with profitable investments. According to the follow-up study, the investments carried out have resulted in 12% lower fuel use and 24% lower CO_2 emissions. The results imply that all operating paper machines should be similarly examined.

10/03072 Energy efficiency improving opportunities in a large Chinese shoe-making enterprise

Yang, M. *Energy Policy*, 2010, 38, (1), 452–462.

Energy consumption and energy intensity reduction opportunities are quite different from one enterprise to another. It is necessary to understand how much energy is used at individual enterprise, where the most energy is consumed and what the best opportunities are to invest in energy efficiency. Auditing energy efficiency was recently undertaken in one of the top 1000 largest Chinese enterprises. The objectives of this paper are to fill a gap in the literature of auditing energy efficiency for a Chinese manufacturing enterprise and to share the audited energy efficiency results. This paper concludes that if the enterprise invests US$1.9 million to improve energy efficiency, the investment will be recovered in about 18 months. The net present value of the investment would be about $9.8 million at a discount rate of 12%. The investment will reduce a large amount of energy consumption at the enterprise based on its figures in 2008, including 15% of electricity, 40% of fuel oil, and 54% of diesel. Carbon reduction is also very cost-effective. Investment of one dollar in the enterprise will help cut carbon emission by 7.95 kg per year and generate $5.30 net revenue in the economic lifetime of the invested technology.

10/03073 Energy saving opportunities in heat integrated beverage plant retrofit

Tokos, H. *et al. Applied Thermal Engineering*, 2010, 30, (1), 36–44.

This paper presents practical applications of mathematical programming for energy integration in a large beverage plant. The opportunities of heat integration between batch operations were analysed by a mixed integer linear programming (MILP) model, which was slightly modified by considering specific industrial circumstances. The feasibility of combined electricity, heating and cooling production was studied using a simplified MILP model, developed for the selection of an optimal polygeneration system. The superstructure includes cogeneration systems with different prime movers (steam turbine and gas turbine), and a trigeneration system with a back-pressure steam turbine. The proposed heat integration scheme and the selected cogeneration system may improve a company's economic performance and reduce its environmental impact.

10/03074 Fuel and energy saving in open pan furnace used in jaggery making through modified juice boiling/concentrating pans

Anwar, S. I. *Energy Conversion and Management*, 2010, 51, (2), 360–364.

In this paper the concept of fins has been used for heating purpose for improving efficiency of open pan jaggery making furnace. Pan is the integral part of these furnaces where boiling/concentration of sugarcane juice take place. Parallel fins were provided to the bottom of main pan and gutter pan of IISR Lucknow 2-pan furnace. Choice for type of fins was based on movement of flames and hot flue gases generated due to combustion of bagasse. Fins helped in more heat transfer to the sugarcane juice being concentrated. Considerable improvement in heat utilization efficiency (9.44%) was observed which resulted in saving of fuel and energy (31.34%).

10/03075 GCPSO in cooperation with graph theory to distribution network reconfiguration for energy saving

Assadian, M. *et al. Energy Conversion and Management*, 2010, 51, (3), 418–427.

Network reconfiguration for loss reduction in distribution system is an important way to save energy. This paper investigates the ability of guaranteed convergence particle swarm optimization (GCPSO) and particle swarm optimization (PSO) in cooperation with graph theory for network reconfiguration to reduce the power loss and enhancement of voltage profile of distribution systems. Numerical results of three distribution systems are presented which illustrate the feasibility of the proposed method by GCPSO and PSO using the graph theory. To validate the obtained results, genetic algorithm (GA) using graph theory is also applied and is compared with the proposed GCPSO and PSO using graph theory.

10/03076 Greek long-term energy consumption prediction using artificial neural networks

Ekonomou, L. *Energy*, 2010, 35, (2), 512–517.

In this paper artificial neural networks (ANN) are addressed in order the Greek long-term energy consumption to be predicted. The multilayer perceptron model (MLP) has been used for this purpose by testing several possible architectures in order to be selected the one with the best generalizing ability. Actual recorded input and output data that influence long-term energy consumption were used in the training, validation and testing process. The developed ANN model is used for the prediction of 2005–2008, 2010, 2012 and 2015 Greek energy consumption. The produced ANN results for years 2005–2008 were compared with the results produced by a linear regression method, a support vector machine method and with real energy consumption records showing a great accuracy. The proposed approach can be useful in the effective implementation of energy policies, since accurate predictions of energy consumption affect the capital investment, the environmental quality, the revenue analysis, the market research management, while conserve at the same time the supply security. Furthermore it constitutes an accurate tool for the Greek long-term energy consumption prediction problem, which up today has not been faced effectively.

10/03077 High-brightness LEDs – energy efficient lighting sources and their potential in indoor plant cultivation

Yeh, N. and Chung, J.-P. *Renewable and Sustainable Energy Reviews*, 2009, 13, (8), 2175–2180.

The rapid development of optoelectronic technology since mid-1980 has significantly enhanced the brightness and efficiency of light-emitting diodes (LEDs). LEDs have long been proposed as a primary light source for space-based plant research chamber or bioregenerative life support systems. The raising cost of energy also makes the use of LEDs in commercial crop culture imminent. With their energy efficiency, LEDs have opened new perspectives for optimizing the energy conversion and the nutrient supply both on and off Earth. The potentials of LED as an effective light source for indoor agricultural production have been explored to a great extent. There are many researches that use LEDs to support plant growth in controlled environments such as plant tissue culture room and growth chamber. This paper provides a brief development history of LEDs and a broad base review on LED applications in indoor plant cultivation since 1990.

10/03078 Modeling of end-use energy consumption in the residential sector: a review of modeling techniques

Swan, L. G. and Ugursal, V. I. *Renewable and Sustainable Energy Reviews*, 2009, 13, (8), 1819–1835.

There is a growing interest in reducing energy consumption and the associated greenhouse gas emissions in every sector of the economy. The residential sector is a substantial consumer of energy in every country, and therefore a focus for energy consumption efforts. Since the energy consumption characteristics of the residential sector are complex and inter-related, comprehensive models are needed to assess the technoeconomic impacts of adopting energy efficiency and renewable energy technologies suitable for residential applications. The aim of this paper is to provide an up-to-date review of the various modelling techniques used for modelling residential sector energy consumption. Two distinct approaches are identified: top-down and bottom-up. The top-down approach treats the residential sector as an energy sink and is not concerned with individual end-uses. It utilizes historic aggregate energy values and regresses the energy consumption of the housing stock as a function of top-level variables such as macroeconomic indicators (e.g. gross domestic product, unemployment, and inflation), energy price, and general climate. The bottom-up approach extrapolates the estimated energy consumption of a representative set of individual houses to regional and national levels, and consists of two distinct methodologies: the statistical method and the engineering method. Each technique relies on different levels of input information, different calculation or simulation techniques, and provides results with different applicability. A critical review of each technique, focusing on the strengths, shortcomings and purposes, is provided along with a review of models reported in the literature.

10/03079 Parametric equations for energy and load estimations for buildings in India

Bansal, N. K. and Bhattacharya, A. *Applied Thermal Engineering*, 2009, 29, (17–18), 3710–3715.

Detailed simulations have been performed for a single zone building to calculate the maximum heating and cooling loads as well as specific annual energy consumption for a single zone building. Numerical results have been used to derive parametric equations as a function of the thickness of insulation as well as the surface to volume ratio (A/V) taking into account the effect of increasing height as well as increasing length and width. For un-insulated building, the energy consumption increases steeply with increasing height, whereas for an insulated building, the energy consumption decreases slightly. For increasing lengths and widths, the change in energy consumption is a mild positive slope. The optimum thickness of the insulation obtained in the paper corresponds to the recommended U-values of roof and the walls in the building code of India, U being the total heat transfer coefficient.

10/03080 Preliminary assessment of the Louisiana Home Energy Rebate Offer program using IPMVP guidelines

Kaiser, M. J. and Pulsipher, A. G. *Applied Energy*, 2010, 87, (2), 691–702.

The Louisiana Home Energy Rebate Offer (HERO) is a residential energy conservation program established in 1999 to provide rebates for qualified applicants to build new homes that are more energy efficient or improve the energy efficiency of existing homes. Energy conservation programmes require careful evaluation because of the high cost to implement the measures and the expectation that they will reduce energy use. The purpose of this paper is to demonstrate that residential energy conservation measures in a hot and humid climate can be evaluated using the International Performance Measurement and Verification Protocol (IPMVP), a best practice methodology commonly used in industrial and commercial performance-based contracts, but rarely, if ever, applied to residential programmes. Using a random sample of 60 HERO participants, statistically significant electricity consumption baseline models were constructed for 90% of households. It was found that more than half of the sample participants consumed more electricity after their efficiency improvement, with an average net household savings of 172 kWh/yr, about 1% pre-retrofit consumption. A description of the baseline model construction, preliminary program evaluation, and recommendations are provided. All program conclusions are considered preliminary until a larger and more comprehensive study is conducted.

10/03081 Preparation of the saving-energy sulphoaluminate cement using MSWI fly ash

Shi, H. *et al. Journal of Hazardous Materials*, 2009, 169, (1–3), 551–555.

MSWI fly ash was used as a major cement raw material in sintering sulfoaluminate cement clinker successfully in the laboratory. Sintering system, mechanical performance, hydration process and microstructure of the clinker was investigated by X-ray diffraction (XRD), scanning electron microscopy (SEM), X-ray fluorescence spectrometry (XRF), etc. The result shows that the clinker can be sintered properly under the temperature of 1200–1300 °C and sintered time of 120 min. Cl^- content in the clinker made with MSWI fly ash is about 1.08%. However most Cl^- cannot leach out in water solution from the hardened cement paste during curing age between 1 d and 28 d because of the Cl^- being combined in clinker minerals and its hydrates. The compressive strength of the sulfoaluminate cement was high in early age while that developed smoothly in later age.

10/03082 Rural energy in China: pattern and policy

Zhang, L. *et al. Renewable Energy*, 2009, 34, (12), 2813–2823.

An overview of energy consumption pattern by available data and the analysis of some relevant aspects of energy policy in rural China are presented in this paper. The most obvious trend is the steady decreased proportion of biomass use, from 70.79% to 30.95%, and increased percentage of coal and electricity use, whereas coal and biomass are the major energy sources in rural areas, accounting for more than 70% of the total rural energy consumption even in 2007. Moreover, the energy consumption varies tremendously across provinces both in total and by fuel types, due to diversities of geographic features, economic development levels and local energy source availability. The rural energy policy and strategy of China have been somewhat unique, characterized by multi-resources, multi-assortments and multi-distribution channels. Some evident transition features can be found for both the rural energy consumption structure and the rural energy policy during the concerned period, that is, from noncommercial energy to commercial energy and from just satisfying energy demand to multi-purposes considering more factors as rural development and environmental protection.

10/03083 The efficient use of energy: tracing the global flow of energy from fuel to service

Cullen, J. M. and Allwood, J. M. *Energy Policy*, 2010, 38, (1), 75–81.

The efficient use of energy is a key component of current efforts to reduce carbon emissions. There are two important factors when assessing the potential gains from energy efficiency technologies: the scale of energy flow and the technical potential for improvement. However, most efficiency analyses consider only the potential gains from known efficiency technologies, while ignoring the complex flow of energy through the chains of conversion devices. In response, this paper traces the global flow of energy, from fuels through to the final services, and focuses on the technical conversion devices and passive systems in each energy chain. By mapping the scale and complexity of global energy flow, the technical areas which are likely to deliver the largest efficiency gains can be identified. The result is a more consistent basis for directing future research and policy decisions in the area of energy efficiency.

10/03084 The synthesis of cost optimal heat exchanger networks with unconstrained topology

Toffolo, A. *Applied Thermal Engineering*, 2009, 29, (17–18), 3518–3528.
The optimization of heat exchanger network (HEN) synthesis still remains an open problem because of the complexity of the space comprising all the possible solutions, and most of the proposed methods introduce simplifying assumptions that mainly affect the topological features of the candidate solutions considered and thus artificially limit the boundaries of the search space. This work is devoted to the pursuit of cost-optimal HENs with unconstrained topology, exploiting the advantages deriving from two graph representations of a HEN. One representation is used by an evolutionary algorithm to manage HEN topology and the other is used by a NLP algorithm to manage heat load distribution among the exchangers. The proposed two-level hybrid optimization method is applied to four test cases taken from the literature about HEN synthesis, among which the well-known Aromatics Plant problem.

10/03085 Vacuum insulation panels for building applications: a review and beyond

Baetens, R. *et al. Energy and Buildings*, 2010, 42, (2), 147–172.
Vacuum insulation panels (VIPs) are regarded as one of the most promising high performance thermal insulation solutions on the market today. Thermal performances three to six times better than still-air are achieved by applying a vacuum to an encapsulated microporous material, resulting in a great potential for combining the reduction of energy consumption in buildings with slim constructions. However, thermal bridging due to the panel envelope and degradation of thermal performance through time occurs with current technology. Furthermore, VIPs cannot be cut on site and the panels are fragile towards damaging. These effects have to be taken into account for building applications as they may diminish the overall usability and thermal performance. This paper is as far as the authors know the first comprehensive review on VIPs. Properties, requirements and possibilities of foil encapsulated VIPs for building applications are studied based on available literature, emphasizing thermal bridging and degradation through time. An extension is made towards gas-filled panels and aerogels, showing that other high performance thermal insulation solutions do exist. Combining the technology of these solutions and others may lead to a new leap forward. Feasible paths beyond VIPs are investigated and possibilities such as vacuum insulation materials (VIMs) and nano insulation materials (NIMs) are proposed.

10/03086 Valuing energy-saving measures in residential buildings: a choice experiment study

Kwak, S.-Y. *et al. Energy Policy*, 2010, 38, (1), 673–677.
Air-conditioning and heating energy-saving measures can cut back the usage of energy. This paper attempts to apply a choice experiment in evaluating the consumer's willingness to pay (WTP) for air-conditioning and heating energy-saving measures in Korea's residential buildings. The trade-offs between price and three attributes of energy-saving (window, facade, and ventilation) are considered for selecting a preferred alternative and derive the marginal WTP (MWTP) estimate for each attribute. The authors also try to test irrelevant alternatives property for the estimation model holds and compare the estimation results of the multinomial logit (MNL) and the nested logit (NL) models. The NL model outperforms the MNL model. The NL model show that MWTPs for increasing the number of glasses and their variety, for increasing the thickness of facade for 1 mm, and for establishing a ventilation system are KRW17,392 (US$18.2), KRW1112 (1.2), and KRW11,827 (12.4), respectively. Overall, the potential consumers have significant amount of WTP.

10/03087 Why don't households see the light?: explaining the diffusion of compact fluorescent lamps

Mills, B. F. and Schleich, J. *Resource and Energy Economics*, 2010, 32, (3), 363–378.
Starting in 2009 the EU ban on the sale of incandescent bulbs will force households to purchase energy-saving compact fluorescent lamps (CFLs). The impact of the ban on consumers will depend on the nature of current barriers to the use of CFLs. This paper employs a Double-Hurdle model to identify distinct barriers to household consideration of CFLs and to the subsequent intensity of adoption using a large survey of German households. Barriers to CFL consideration are found to be low for all households, except those with very low incomes. Barriers to CFL consideration are, however, strongly linked to the residential characteristics of low-income households like small size and to the lack of household knowledge of energy consumption. CFLs use will increase after the ban mainly through a rise in the intensity of adoption. But the ban will be costly to consumers because the range of applications where households chose to employ CFLs is limited, particularly for high income households.

17 ENERGY CONVERSION AND RECYCLING

10/03088 A thermal model of the immobilization of low-level radioactive waste as grout in concrete vaults

Shadday, M. A. *Nuclear Engineering and Design*, 2009, 239, (10), 2185–2195.
A salt solution, from radioactive waste generated by the production of plutonium and tritium in nuclear reactors at the Savannah River Site, will be mixed with cement and flyash/slag to form a grout which will be poured into above ground concrete vaults. The curing process is exothermic, and a transient thermal model of the pouring and curing process is herein described. A peak temperature limit of 85 °C for the curing grout restricts the rate at which it can be poured into a vault. The model is used to optimize the pouring.

10/03089 Catalytic coprocessing of waste plastics and petroleum residue into liquid fuel oils

Siddiqui, M. N. and Redhwi, H. H. *Journal of Analytical and Applied Pyrolysis*, 2009, 86, (1), 141–147.
Waste plastics of different types were catalytically coprocessed with petroleum residue of light Arabian crude oil in the presence of a number of catalysts. The purpose of the study was to explore effects of various conditions such as catalyst type, amount of catalyst, reaction time, pressure and temperature on the product distribution. The waste plastic studied included low-density polyethylene (LDPE), high-density polyethylene (HDPE), polystyrene (PS) and polypropylene (PP). A series of single (waste plastic with catalyst) and binary (waste plastic and residue with catalyst) reactions were carried out in an autoclave reactor under variable reaction conditions. The reaction conditions used were 1, 3 and 5 wt.% catalysts, 30–120 min reaction time, 400–430 °C reaction temperature and 500–1200 psi hydrogen pressure. The product distribution achieved for residue/plastic/catalyst system showed higher yields of liquid fuels as compared to residue/plastic system. Hydrocarbon gases were formed as well along with heavy oils, insoluble gums and coke. At the reaction conditions of 3 wt.% NiMo catalyst, 90 min reaction time, 1200 psi hydrogen gas pressure, 430 °C temperature and residue to plastic feed ratio of 3:2 (wt.) afforded maximum conversion of the plastics into liquid fuel oils.

10/03090 Condenser heat recovery with a PV/T air heating collector to regenerate desiccant for reducing energy use of an air conditioning room

Sukamongkol, Y. *et al. Energy and Buildings*, 2010, 42, (3), 315–325.
This paper presents an experimental test along with procedures to investigate the validity of a developed simulation model in predicting the dynamic performance of a condenser heat recovery with a photovoltaic/thermal (PV/T) air heating collector to regenerate desiccant for reducing energy use of an air conditioning room under the prevailing meteorological conditions in tropical climates. The system consists of five main parts: living space, desiccant dehumidification and regeneration unit, air-conditioning system, PV/T collector, and air-mixing unit. The comparisons between the experimental results and the simulated results using the same meteorological data of the experiment show that the prediction results simulated by the model agree satisfactorily with those observed from the experiments. The thermal energy generated by the system can produce warm dry air as high as 53 °C and 23% relative humidity. Additionally, electricity of about 6% of the daily total solar radiation can be obtained from the PV/T collector in the system. Moreover, the use of a hybrid PV/T air heater, incorporated with the heat recovered from the condenser to regenerate the desiccant for dehumidification, can save the energy use of the air-conditioning system by approximately 18%.

10/03091 CO_2 recycling by reaction with renewably-generated hydrogen

Kent Hoekman, S. *et al. International Journal of Greenhouse Gas Control*, 2010, 4, (1), 44–50.
A laboratory-scale reactor system was built and operated to demonstrate the feasibility of catalytically reacting carbon dioxide (CO_2) with renewably-generated hydrogen (H_2) to produce methane (CH_4) according to the Sabatier reaction: $CO_2 + 4H_2 \rightarrow CH_4 + 2H_2O$. A cylindrical reaction vessel packed with a commercial methanation catalyst (Haldor Topsøe PK-7R) was used. Renewable H_2 produced by electrolysis of water (from solar- and wind-generated electricity) was

fed into the reactor along with a custom blend of 2% CO_2 in N_2, meant to represent a synthetic exhaust mixture. Reaction conditions of temperature, flow rates, and gas mixing ratios were varied to determine optimum performance. The extent of reaction was monitored by real-time measurement of CO_2 and CH_4. Maximum conversion of CO_2 occurred at 300–350 °C. Approximately 60% conversion of CO_2 was realized at a space velocity of about 10,000 h^{-1} with a molar ratio of H_2/CO_2 of 4/1. Somewhat higher total CO_2 conversion was possible by increasing the H_2/CO_2 ratio, but the most efficient use of available H_2 occurs at a lower H_2/CO_2 ratio.

10/03092 Exergy recovery in regasification facilities – cold utilization: a modular unit

Dispenza, C. *et al. Applied Thermal Engineering*, 2009, 29, (17–18), 3595–3608.

The paper deals with the problem of cold recovery for direct utilization both in the site of regasification facility and far from it. A modular LNG regasification unit is proposed having the regasification capacity of 2 billion standard cubic metres/year of gas. The modular plant is based on use of a power cycle working with ethane or ethylene which allows operation of cold energy transfer, contained in LNG to be regasified, in a range of temperatures suitable for multipurpose use of cold, reducing regasification process irreversibility. Some electric energy is produced by the power cycle, but the own mission of modular unit proposed is addressed to deliver cold suitable for industrial and commercial use in the proper temperature range. The option considers, also, the use of carbon dioxide as a secondary fluid for transfer of cold from regasification site to far end users. This option seems very attractive due to expected wide future exploitation of LNG regasification in the world. Results of a detailed thermodynamic and economic analysis demonstrate the suitability of the proposal.

10/03093 Feasibility of hydraulic power recovery from waste energy in bio-gas scrubbing processes

Bansal, P. and Marshall, N. *Applied Energy*, 2010, 87, (3), 1048–1053.

This paper investigates the feasibility of recovering waste energy from typical bio-gas upgrading facilities by means of a hydraulic turbine, and presents analysis of different types of hydraulic power recovery turbines. A selection method and analysis is developed which can be applied to an existing process to determine the effectiveness and energy savings of such a system for its economic viability. A practical testing rig was designed and constructed to verify the reliability and consistency of data for the both selection and optimization techniques. It was found that a centrifugal pump operating in reverse flow, essentially as a turbine, could be a possible option for waste energy recovery.

10/03094 Light olefins and light oil production from catalytic pyrolysis of waste tire

Dũng, N. A. *et al. Journal of Analytical and Applied Pyrolysis*, 2009, 86, (2), 281–286.

This paper investigates the catalytic activity of a pure silica MCM-41 synthesized via silatrane route and ruthenium and MCM-41 (Ru/MCM-41) in waste tyre pyrolysis. The experimental results showed that the presence of catalysts strongly influenced the yield and nature of products. Namely, the gas yield increased at the expense of liquid yield. In addition, a considerable high yield of light olefins, four times higher than non-catalytic pyrolysis, can be achieved for Ru/MCM-41 catalyst. Furthermore, the uses of catalysts produced much lighter oil and there was a drastic increase in the concentration of single ring aromatics in accordance to a reduction in polycyclic aromatic compounds in the derived oils. Ru/MCM-41 produced the lightest oil and the oil has the highest concentration of mono-aromatics. The high activity of catalysts, particularly Ru/MCM-41 was discussed in relation with the catalyst characterization results obtained from various techniques including temperature-programmed desorption using NH_3, H_2-chemisorption, XRD, N_2-adsorption/desorption analysis, and temperature-programmed oxidation.

10/03095 Process integration in bioprocess industry: waste heat recovery in yeast and ethyl alcohol plant

Rašković, R. *et al. Energy*, 2010, 35, (2), 704–717.

The process integration of the bioprocess plant for production of yeast and alcohol was studied. Preliminary energy audit of the plant identified the huge amount of thermal losses, caused by waste heat in exhausted process streams, and reviled the great potential for energy efficiency improvement by heat recovery system. Research roadmap, based on process integration approach, is divided on six phases, and the primary tool used for the design of heat recovery network was Pinch Analysis. Performance of preliminary design are obtained by targeting procedure, for three process stream sets, and evaluated by the economic criteria. The results of process integration study are presented in the form of heat exchanger networks which fulfilled the utilization of waste heat and enable considerable savings of energy in short payback period.

10/03096 Production of activated carbon by waste tire thermochemical degradation with CO_2

Betancur, M. *et al. Journal of Hazardous Materials*, 2009, 168, (2–3), 882–887.

The thermochemical degradation of waste tyres in a CO_2 atmosphere without previous treatment of devolatilization (pyrolysis) in order to obtain activated carbons with good textural properties such as surface area and porosity was studied. The operating variables studied were CO_2 flow rate (50 and 150 mL/min), temperature (800 and 900 °C) and reaction time (1, 1.5, 2, 2.5 and 3 h). Results show a considerable effect of the temperature and the reaction time in the porosity development. Kinetic measurements showed that the reactions involved in the thermochemical degradation of waste tyre with CO_2, are similar to those developed in the pyrolysis process carried out under N_2 atmosphere and temperatures below 760 °C, for particles sizes of 500 μm and heating rate of 5 °C/min. For temperatures higher than 760 °C the CO_2 starts to oxidize the remaining carbon black. Activated carbon with a 414-m^2/g surface area at 900 °C of temperature, 150 mL/min of CO_2 volumetric flow and 180 min of reaction time was obtained. In this work it is considering the no reactivity of CO_2 for devolatilization of the tyres (up to 760 °C), and also the partial oxidation of residual char at high temperature for activation (>760 °C). It is confirmed that there are two consecutive stages (devolatilization and activation) developed from the same process.

10/03097 Using information of the separation process of recycling scrap tires for process modelling

Pehlken, A. and Müller, D. H. *Resources, Conservation and Recycling*, 2009, 54, (2), 140–148.

Modelling recycling processes are a challenge because there are few specific data available. Various materials are firmly connected to each other, making an ideal separation success nearly impossible. Scrap tyre recycling is discussed as the case study with respect to some of the main key processes such as crushing, grinding and sieving. Useful information can be accumulated with data received from particle size distribution. Assessing the information of the separation for modelling purposes with the availability of data ranges and identifying uncertainties is the focus of the article. Modelling recycling processes and the assessment of uncertainty are firmly connected, otherwise the model provides a lack of reliability due to parameter uncertainties. When modelling a recycling process, the known and unknown uncertainties become important parameters to consider. Due to the fact that residues of scrap tyres always vary in their composition and material flows, only data ranges can be used as input parameters.